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working paper
department
of economics

THE EFFECT OF TAXES ON LABOR SUPPLY

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Number 254

February 1980

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FIRST DRAFT
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SEPTEMBER 1979

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Paper Prepared for Brookings Conference on Taxation,
October 18-19, 1979

I would like to thank E.C. Brown, P.A. Diamond, and D. Holland for helpful suggestions. M. Chang, J. Hamilton and P. Ruud provided research assistance.

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Introduction

The effect of taxes on labor supply introduces interesting questions in economic theory, econometrics, and public finance. Since the greatest share of federal tax revenues, approximately 45 percent, is raised by the individual income tax, we are certainly interested in its effects on economic activity. The federal income tax is based on the notion of 'ability to pay'; and its progressive structure has received wide acceptance. The income tax has not been thought to induce large economic distortions so that it has been generally accepted as probably the best way to raise revenue where an unequal distribution of income exists. At the same time we finance social security by FICA which is a proportional tax with an upper limit. As both the tax rate and limit have grown rapidly in recent years, FICA taxes have become the subject of much controversy, especially since it has such a large relative effect on the working poor. In this paper we consider three groups in the population - husbands, wives, and female headed households - to assess the effect of taxes on labor supply. Our findings somewhat contradict received knowledge to the extent that we find a substantial economic cost to the presence of income taxation. Our most impostant new finding is that while previous research which demonstrates that the tax induced change in the net wage does not greatly affect hours worked for husbands is supported, an important income effect is present. Thus, if Hicksian deadweight loss is accepted as the appropriate measure of economic cost we find that deadweight loss is a substantial proportion of tax revenues raised. Since the proportion of deadweight loss increases with the progressivity of the tax, an important tradeoff exists between the equity and efficiency aspects of the income tax. The economic cost of a progressive income tax may be higher than has been previously realized.

To measure empirically the effect of taxes on labor supply, problems in economic theory and econometrics need to be treated. First, the effect of progressive taxation is to create a convex, nonlinear budget set where the net, after tax wage depends on hours worked. Since most of consumer theory is based on constant market prices which are independent of quantity purchased, theoretical notions such as the Slutsky equation need to be modified to assess the effect of a change in the tax rate. Theoretical problems increase in complexity when we realize that other provisions of the tax code such as the earned income credit, the standard deduction, and FICA together with transfer programs such as AFDC create important nonconvexities in the budget set. Then certain portions of the budget set cannot correspond to utility maximizing points. Little definite knowledge can be gained by a theoretical analysis of the effect of taxation. In fact, we cannot usually tell whether an increase in tax rates will increase or decrease hours worked. Nor can we decide how an increase in exemptions or other similar changes will effect hours worked. Thus, only empirical investigation can determine the sign and magnitude of the effect of taxation.

Appropriate econometric techniques to measure the effect of taxation also need to treat the nonlinearity of the budget sets which taxation creates. Other problems such as components of the stochastic specification, limited dependent variables, and unobserved wages for nonworkers arise. Econometric procedures to handle these problems, many of which have only recently been developed, are used to estimate labor supply functions for husbands, wives, and female headed households. Then the relative size of income and substitution effects can be determined as well as the compensated labor supply function so that deadweight loss calculations can be made.

The plan of the paper is as follows. Section 1 considers the theory of labor supply with taxes. The effect of the nonlinearity of the budget sets complicates the analysis so few definite conclusions can be reached. In Section 2 we develop an econometric model of labor supply so that the problems created by convex and nonconvex budget sets can be solved. Section 3 discusses the various tax systems in the United States. The federal income tax, FICA tax and state income taxes all are used to develop the appropriate budget sets. We also discuss AFDC, social security benefits, and a negative income tax to determine how they affect labor supply budget sets. In Section 4 we present empirical estimates for husbands, wives and female headed households. We also calculate the economic cost of the tax system for certain individuals. Because of small numbers in cross section samples, and measurement problems, high income individuals are difficult to treat within the context of a labor supply model. Thus, in Section 5 we review the individual questionnaire data for high income people. It is interesting to note that it agrees broadly with the econometric evidence. In Section 6 we review the evidence from the negative income tax experiments and from samples of social security beneficiaries. These individuals face extremely high marginal tax rates so that interesting evidence of the effect of taxes is produced in these situations.

1. The Theory of Labor Supply with Taxes

In a world without taxes, the theory of labor supply is characterized by the same conditions which characterize the theory of consumer demand. That is, the Slutsky conditions completely exhaust the theoretical restrictions on consumer response to a price change. Thus, in most previous work on the effect of taxation on labor supply, the authors consider taxes as lowering the net, after tax wage. Using the Slutsky equation

$$(1.1) \qquad \frac{dh}{dw} = \left.\frac{\partial h}{\partial w}\right|_{u = \bar{u}} + h \frac{\partial h}{\partial y}$$

We decompose the change in hours into the substitution effect and the income effect. Since labor is supplied while leisure is demanded, the sign of the substitution effect is positive, while the sign of the income effect is negative if leisure is a normal good. We can conclude that the sign of the sum of the effects is indeterminate. It might then be considered the goal of empirical analysis to determine the sign and magnitude of the effect of taxation.

However, this approach is seriously misleading in all cases except one. Consider the two good diagram of Figure 1.1. The composite good is used as numeraire so consumption is measured on the vertical axis with hours supplied on the horizontal axis. Non-labor income is denoted by y. The original pre-tax market wage is w and preferred hours of labor are h*. The effect of a proportional tax is then to lower the net, after tax wage to $w_t = w(1-t)$. Depending on the individual's preferences,

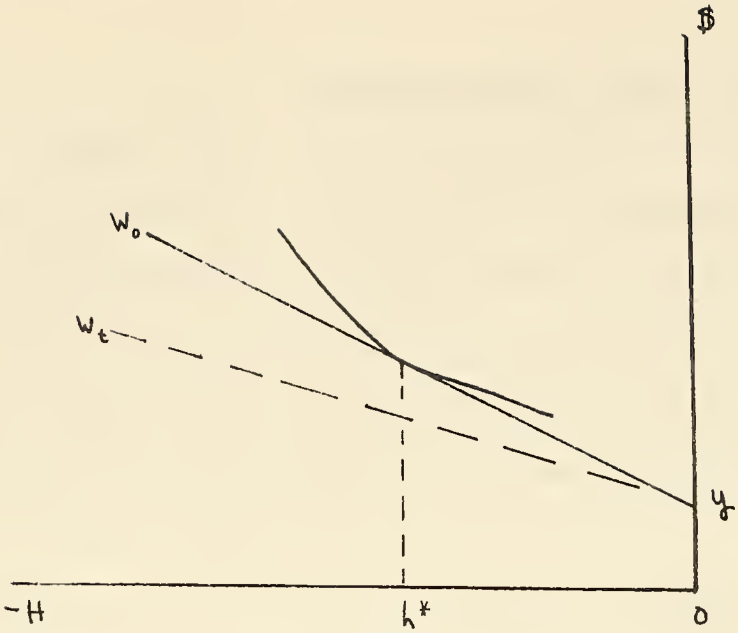

Figure 1.1

desired hours of work, h* can either increase or decrease according to equation (1.1). Thus, in the case of proportional taxation, the traditional analysis is correct. But, only for proportional taxes is the analysis so simple. What makes the proportional tax case so special is that non-labor income y is unaffected by the tax which is implicitly assumed to be only a tax on labor income. If y were also subject to taxation at rate t, we would have to take account of another income effect which would cause h* to rise. Equation (1.1) would then need to be modified to account for taxation of y to

$$(1.1a) \quad \frac{dh}{dt} = \frac{\partial h}{\partial w}\bigg|_{u=\bar{u}} \frac{dw}{dt} + h\frac{\partial h}{\partial y} + \frac{\partial h}{\partial y}\frac{dy}{dt}$$

When we consider the effect of taxation, the income and substitution effect of a change in the wage as well as the change in non-labor income must be accounted for. This equation becomes the key device in analyzing the effect of taxation on desired hours of work. The total effect of taxation is still indeterminate but a complication has been added since changes in both w and y must be considered. In cases of progressive taxation or government tax and transfer programs, both w and y are affected. The traditional analysis has neglected to account for the effect on y of the tax system. We now consider how the analysis changes when non-proportional tax systems are considered.

Let us first analyze the simplest case, that of a progressive tax on labor income so that the marginal tax rate is non-decreasing. In figure 1.2 three marginal tax rates are considered, t_1, t_2, t_3, which lead to three after-tax net wages, w_1, w_2, w_3, where $w_i = w(1-t_i)$. H_1 and H_2 correspond to kink point hours which occur at the intersection of two tax brackets. But an important addition to the diagram are the "virtual" incomes y_2 and y_3, which follow from extension of a given budget segment to the vertical axis. They are denoted as virtual income because if the individual faced the linear budget set $B_2 = (w_2, y_2)$, he would still choose hours of work h* as in Figure 1.2. In assessing the effect of taxation on labor supply, two questions arise. How does h* in figure 1.2 differ from the no-tax situation of figure 1.1? And how is h* in figure 1.2 affected by a change in the market wage w or the tax rates, t_i?

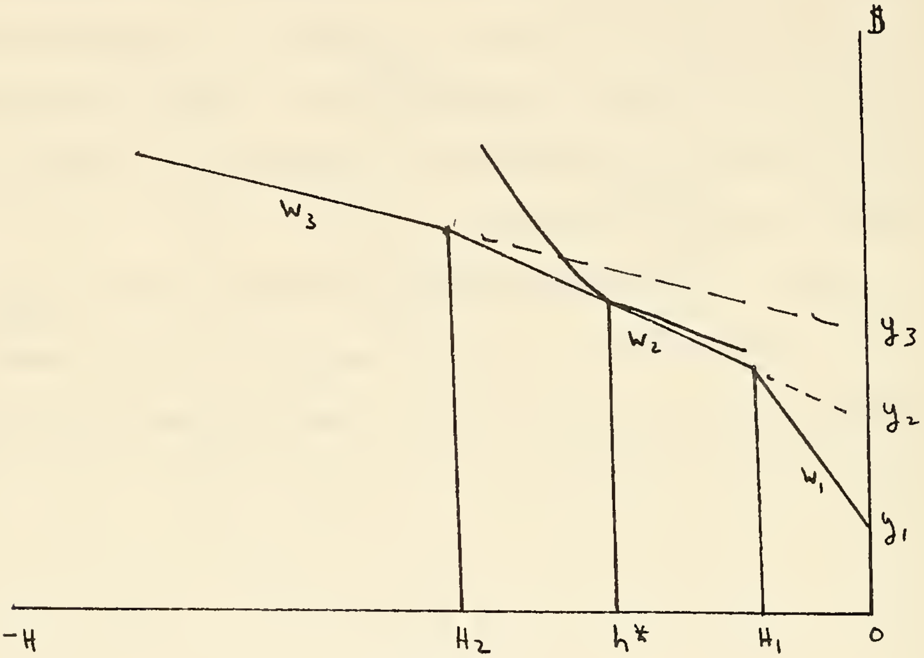

Figure 1.2

To consider the first question in figure 1.3 we combine figures 1.1 and 1.2. We see that no general effect can be identified. If the individual's h* falls on the first budget segment $B_1 = (w_1, y_1)$ we are back in the case of Figure 1.1 with offsetting income and substitution effects. Alternatively if h* falls on either B_2 or B_3 then the net wage is lower than w which leads

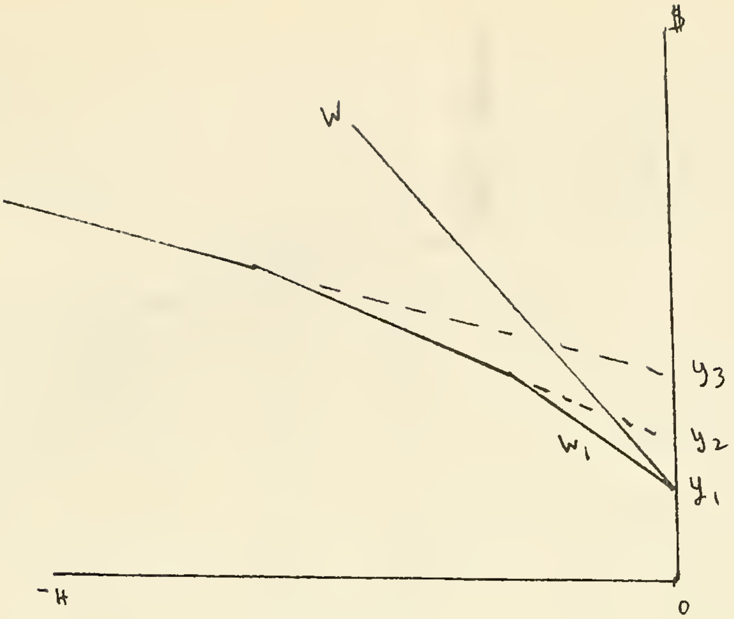

Figure 1.3

to an income and substitution effect, while virtual income y_2 or y_3 exceeds y_1 and a further income effect from equation (1.1a) is created which would reduce labor supply.[1] One result which does follow is that on the budget segment B_2 or B_3 labor supply is less than it would be if the analysis were based on (w_2, y_1) or (w_3, y_1); that is, if the effect of the virtual income were ignored.

To answer the second question we initially consider an increase in the market wage from w to w'. In figure 1.4 we see that this wage change leads to a clockwise rotation of the budget set. The effect of the rotation is to raise the w_i, but it also leaves the virtual incomes unchanged. For instance, the virtual income y_2 is $y_2 = E_1(\frac{t_2-t_1}{1-t_1})-y_1(\frac{1-t_2}{1-t_1})$ where E_1 is the earnings limit for the first tax bracket. Thus, the virtual incomes depend only on the tax system and nonlabor income, y_1. Therefore, so long as the individual's preferred hours of work h* remain on the same budget segment B_i, the effect of a wage change can be analyzed

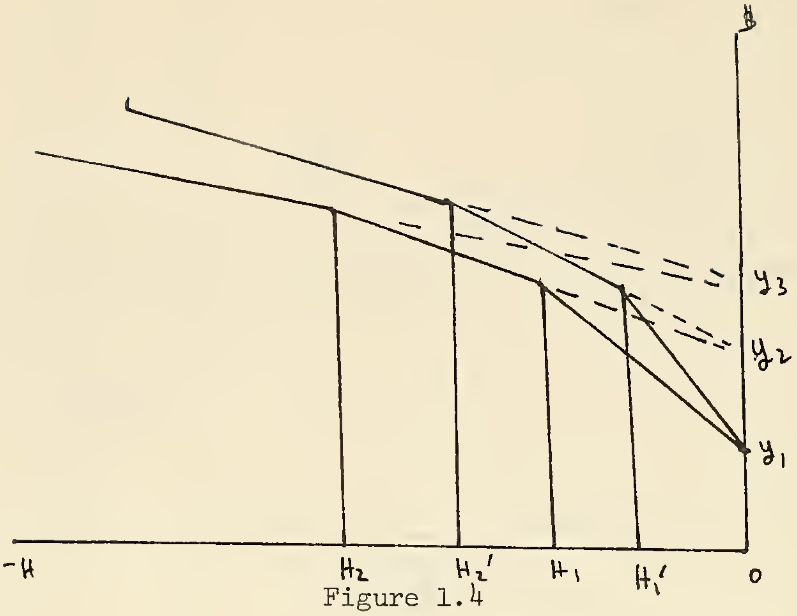

Figure 1.4

using the traditional local analysis which is contained in the Slutsky eqn (1.1a

The effect of a change in a tax rate t_i depends on which t_i changes. To take the simplest case, suppose t_3 rises so that in figure 1.2 the w_3 segment rotates counterclockwise. Then virtual income y_3 also rises. We have the same effect as before where the change in wage alone induces both an income and substitution effect and the change in virtual income induces more labor supply from equation (1.1a). It is important to note also that a person whose preferred hours were previously on the third budget segment B_3 so that $h^*>H_2$ may now shift down to the second budget segment B_2 so that $H_1<h^*<H_2$ if the substitution effect is large enough. Individuals whose preferred hours were less than H_2 before the change will not be affected. However, if the tax rate were to decrease we could again have people shifting from the second segment to the third segment because of the substitution effect. For these cases, we need "global" information on the individual's preferences, since the local information in the Slutsky equation is not sufficient to analyze the possible changes. Now if either

t_1 or t_2 were to change, the situation is more complicated since all later budget segments are also affected. However, the later budget segments are affected only by a change in their virtual income since the net wage remains the same. Thus, if t_1 rises, for those individuals with $h^*>H_1$, the effect of the tax change is to cause their preferred hours to rise. For people whose $h^*\leq H_1$ initially only w_1 changes (although y_1 may change also) so that the Slutsky equation can be used. Lastly suppose one of the tax bracket limits E_i changes. If E_1 is lowered, all virtual incomes on later budget segments fall. Therefore if initially $h^*>H_1$ we have a similar qualitative effect to a rise in t_1. Preferred hours of work will rise. For an individual whose initial $h^*\leq H_1$ but with E_1' have $H'<h^*$ the analysis is more complicated. They may switch to B_2 with its lower net wage, and higher virtual income or they may decrease their desired hours of work so that $h^*<H'_1$ and they remain on the first segment.

From the analysis of the progressive tax case we see that very few general propositions can be deduced about the effect of taxes on labor supply. The piecewise linear progressive tax system is defined by a sequence of budget segments $B_i = (w_i, y_i)$ of net wages and virtual incomes for the individual over a set of hours (H_i, H_{i+1}). Some limited results are possible for changes in t_i and E_i for individuals whose initial hours of work are on a subsequent budget segment $B_i + j$, $j>0$. But to assess B_{i+j} adequately the effect of taxation we really need to know the individual's preferences or equivalently, his utility function. We will show how knowledge of his utility function arises in the process of estimating his labor supply function so that numerical computations of the effect of taxation can be carried out.

When we do not have a progressive tax system, matters become more complex since the budget set is no longer convex.[2] Non-convex budget sets arise from the presence of government transfer programs. The three most important programs of this type are AFDC, Social Security benefits, and a negative income tax (NIT) program. In Figures 1.5 and 1.6 we show the two most common types of non-convex budget sets.[3] In the

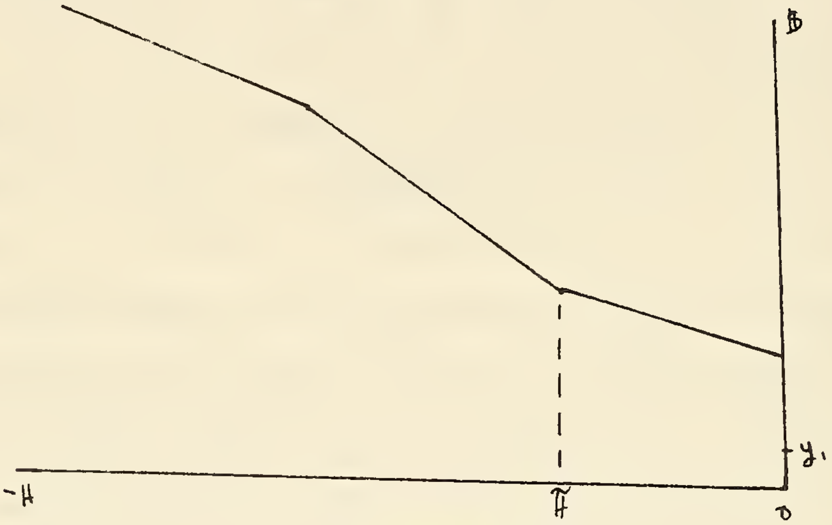

Figure 1.5

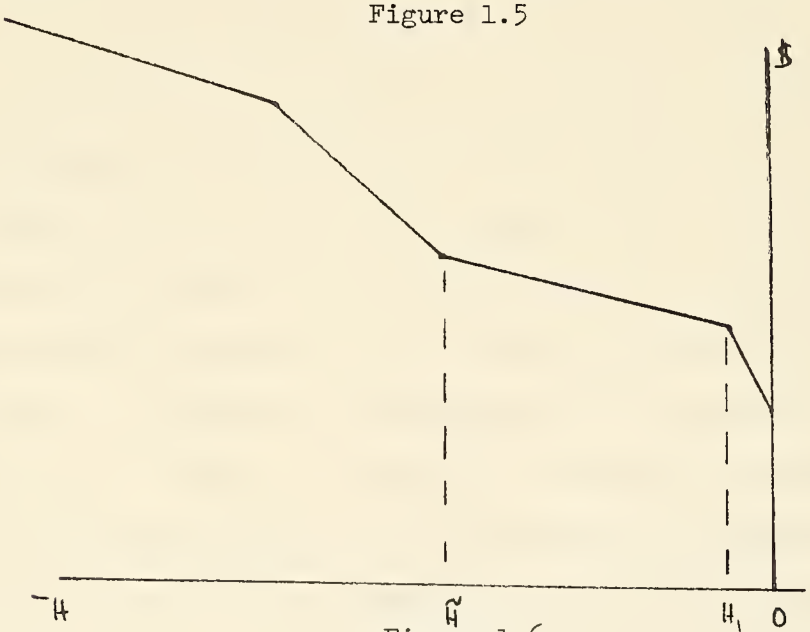

Figure 1.6

first type of budget set used in the NIT experiments, and in the majority of AFDC programs, non-labor income is raised by the amount of the government transfer. The individual then faces a high marginal tax rate, usually .4 or higher, until he reaches $\tilde{H}$, the breakeven point at which all benefits have been taxed away. Beyond the breakeven point, the individual rejoins the federal tax system, here taken to be convex. Figure 1.6 has one additional complication which arises as an earnings disregard in Social Security benefits or as a maximum payment amount in some AFDC programs. Hours up to H_1 are taxed only at FICA rates where H_1 is determined by E_1. Beyond this point, the individual faces the high marginal rates until breakeven hours are again reached. On *a priori* grounds, almost nothing can be said about the effect of taxation in the non-convex budget case. The added complication arises from the possibility of multiple tangencies between indifference curves and the budget set.

Figures 1.7 and 1.8 demonstrate two cases of multiple tangencies although actual cases may be even more complex due to the possibility of skipping entire budget segments. The possibility exists of having multiple

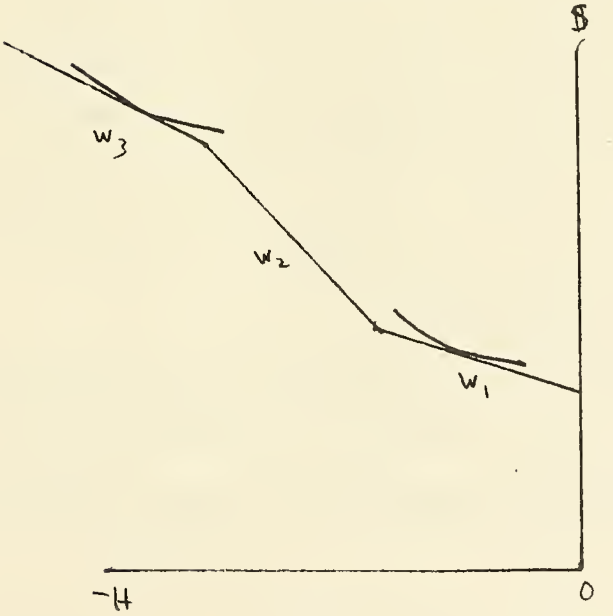

Figure 1.7

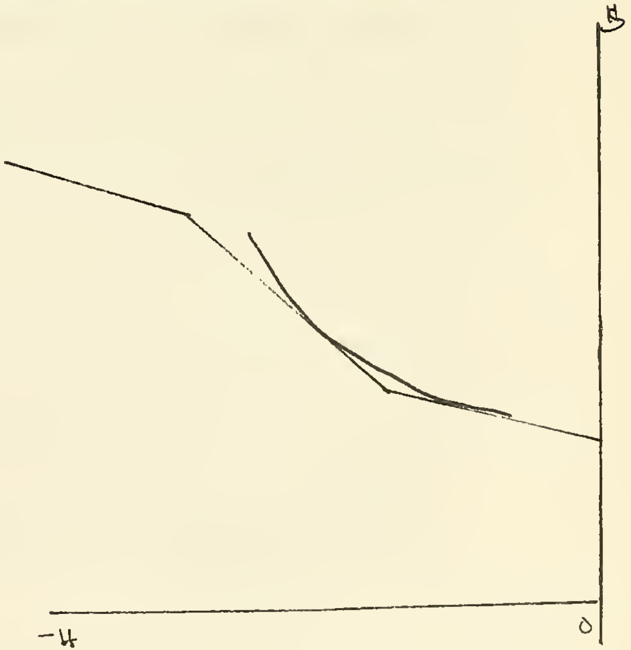

Figure 1.8

optima as in figure 1.7 because $w_1 < w_3$ while $y_1 < y_3$. In the convex case this possibility does not arise because as w_i falls y_i is rising. To determine the global optimum we need to have knowledge of the utility function. Figure 1.8 demonstrates the case of a joint tangency the possibility of which arises with each non-convex segment. Small changes in the wage or any parameter of the tax system can then lead to large changes in desired hours of work.

In the convex budget case, we must always have a tangency which is unique and which represents the global optimum if desired hours are positive. For if we had two tangencies we could connect the two points, and the connecting lines which would lie inside the original budget set would represent preferred points by the assumed concavity of preferences.[5] Furthermore, the effect on h* of a change in the market wage, taxes, or the earnings limits is "smooth" in an appropriate mathematical sense that the change is continuous and differentiable. For the non-convex case, this reasoning no longer follows since the line connecting the multiple tangencies no longer lies within the budget set. Thus, multiple tangencies may occur. Likewise, the effect of changes in the budget set are no longer smooth, since a small change may cause a jump in desired hours from an initial tangency to the neighborhood of another initial tangency. Thus, it seems that no general propositions hold. The Slutsky equation (1.1) is not usable since the possibility of a jump from one budget segment to another is always present.

We briefly consider the cases where we could say something definite in the convex case: a rise in t_1 or a drop in E_1 for individuals not on the first segment. For individuals who remain on the convex budget segments like w_2 and w_3 in figure 1.7 virtual incomes again fall while w_i remains constant so that the local effect is again a rise in desired hours of work. But one cannot rule out the possibility of a non-local jump down to the first segment or even withdrawal from the labor force entirely. Similar possibilities exist if E_1 is decreased. Thus, the analysis of the non-convex case cannot proceed without knowledge about the form of the individual's utility function.

A last issue that we should consider is the effect of taxation on labor force participation. Some previous studies model the participation decision and hours decision separately, but the theoretical grounds for doing so are extremely implausible. Thus, we treat them together where the participation model requires less information--only whether $h^*>0$. Since non-participation is the outcome of a corner solution to the utility maximization problem, in the convex budget case, the analysis is straightforward. Figure 1.9 shows the non-participation decision which depends only on w_1 and y_1. Thus, if taxes only affect w_1 by lowering it from the market wage, participation is decreased in the population. As w_1 rises as the initial tangency of the budget set and the indifference curve we have the net reservation wage which is the minimum wage, given y_1, that causes $h^*>0$. A fall in y_1 increases participation, an effect which may be created by the taxation of a spouse's income. No effect is created by

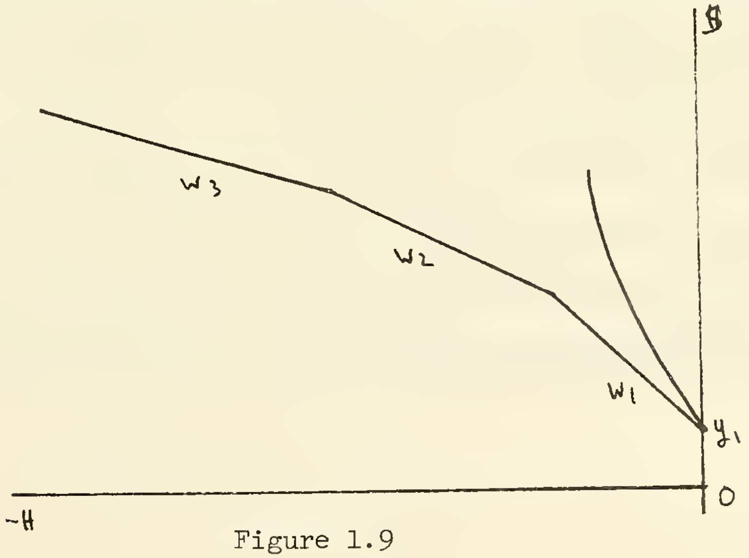

Figure 1.9

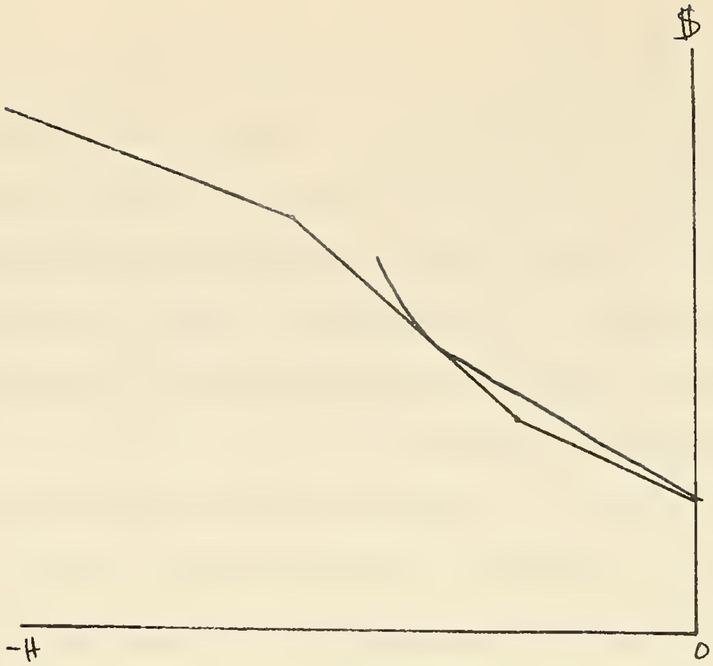

Figure 1.10

changes in any tax rate beside t_1 or any earnings limit, E_i. In the case of a non-convex budget set many tax rates or earnings limits may matter because of the possibility of a joint tangency as in figure 1.10. Thus, the complete budget set must be considered in analyzing the participation decision. Hausman (1979b) develops a model for this case and discusses the various possibilities. But since the effect of the tax and transfer systems is to raise non-labor income and lower the net wage the effect of further changing either component of B_1 is to lower participation in the population, even in the non-convex case. Changes in the parameters of the other budget segments are not easily analyzed, and their effect cannot be stated on a priori grounds.

We now turn briefly to other theoretical considerations, some of which can be treated and others left to future research. First, we consider the case where the market wage may depend on hours worked. Lewis (1956) has emphasized this consideration. It seems possible that part-time jobs may pay less than full-time jobs due to fixed costs in the production process.[6] But, to the extent that the wage-hours locus can be represented by a piecewise linear relationship, no essential complications arise beyond the presence of a non-convexity which had previously arisen in the theory. For example, suppose that the market wage is w up to twenty hours and beyond it rises to fw, f>1.[7] Then figure 1.11 shows that a non-convexity arises as $\hat{H}$ = 20 hrs. A nonconvexity is introduced at $\hat{H}$ and $\tilde{w}_2$, $\tilde{w}_3$ and y_3 are changed. But a labor supply model which can treat figures 1.7 and 1.8 can also treat the case of figure 1.11 since no essential change in the budget set has occurred.

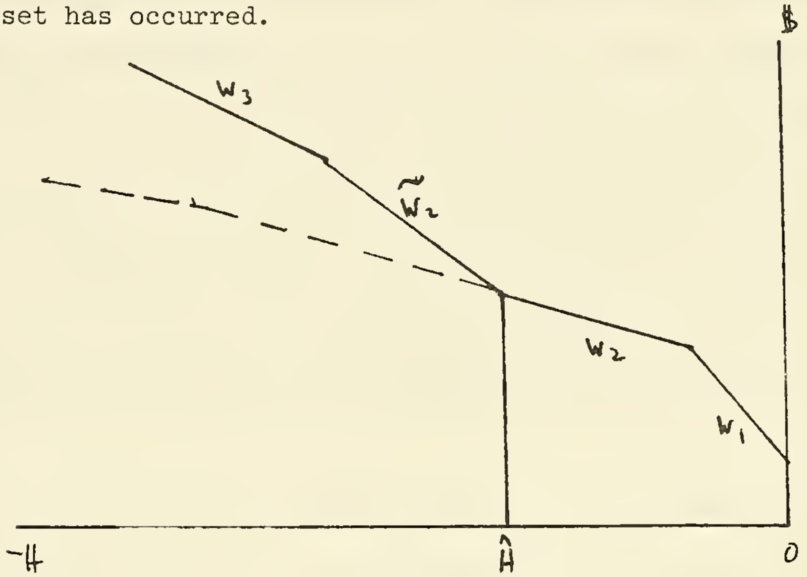

Figure 1.11

Another set of issues that are less easily treated is that individuals may face quantity restrictions in labor supply. That is, h* may not be possible for systematic reasons. Certainly "involuntary" unemployment falls into this category. In the next section we will demonstrate econometric procedures to handle this problem. Thus, in principle, we can estimate the underlying demand function or preference structure and analyze the effect of taxes. But a more difficult problem is to ascertain if individuals are actually constrained. Endless debates on the possibility of involuntary unemployment highlight this problem. Furthermore, survey questions on the ability to work more hours are very untrustworthy. Without better data it seems extremely difficult to put quantity constraints into an empirical model. It is to be hoped that further research on this subject will be done soon.

This type of labor supply theory also does not adequately treat the type of jobs people take or their intensity of work while on the job.[8] An effect of taxes is to make nonpecuniary rewards more attractive so that a measure of earnings may seriously misrepresent the preference comparisons being made among jobs. Academics need hardly be reminded of this fact in the present world of falling real academic wages. Yet it is doubtful that this problem will ever be completely solved. "Perks" from a job could be evaluated monetarily and included in earnings. But we cannot hope to measure adequately certain types of non-monetary rewards to jobs.

A last consideration is intertemporal aspects of the model. We have considered a static world devoid of human capital considerations and intertemporal factors such as savings. But intertemporal issues may be quite important for new entrants into the labor market and for individuals close to retirement. The eighty-hour weeks put in by young lawyers will be rewarded in the not-too-distant future so that current compensation is an inadequate measure of earnings. Furthermore, issues of on-the-job training may be important. We try to minimize these potential problems by restricting our sample in terms of age and type of job. Lastly, as we shall discuss later, intertemporal problems are probably most important when discussing the effect of Social Security benefits. But, in the main part of the paper, the static model is used.

In this section we have considered from a theoretical point of view the effect of taxes on labor supply. The Slutsky equation which has been traditionally used to analyze the problem is inadequate except for the case of a proportional tax. Progressive taxation results in a convex budget constraint which leads to a multiplicity of net wages and virtual incomes. We see that except for a few cases the effect of a change in the tax rate cannot be determined on *a priori* grounds even if reasonable assumptions are made such as leisure being a normal good. Government tax and transfer programs result in non-convex budget sets which are even more difficult to analyze theoretically. Thus, we now turn to the econometrics of the problem so that models can be estimated. From the estimated models we can assess the effect of taxation. However, as with all models we discuss certain aspects of the problem which have not been included. The results should be interpreted with this limitations in mind.

Notes

[1] It may well be this latter income effect which creates the appearance of a backward bending labor supply curve which has been found in many empirical studies. The important point here is that not only do we have a income effect from the change in wage, but virtual income also rises due to the effect of the tax system.

[2] As we will discuss subsequently, even the federal tax system is not truly convex because of the effect of Social Security payments, the earned income credit, and the standard deduction. However, it may well be the case that treating taxes in a convex budget set is a sufficiently good approximation for empirical work.

[3] A non-convexity may also arise, not from the tax system, but due to fixed costs to working, e.g., Hausman (1979). We will discuss fixed costs in the next section.

[4] See Hanoch and Honig (1978) for a theoretical analysis of the Social Security case. They also compute numerical results for the case of a Cobb-Douglas utility function. However, for reasons to be discussed later, it is likely that their budget set is not strictly correct due to the possible effect of current earnings on future benefits.

[5] See Hausman (1979b) for further analysis and implications of this case.

[6] The necessity of paying benefits, except for Social Security payments, is not a sufficient reason when total compensation is taken into account. Of course, most studies use the gross wage and neglect benefits due to lack of data.

[7] Reasons also exist which might cause $f<1$. Then another convex segment would result.

[8] To the extent that wages reflect intensity of work, this problem may not be too serious. However, for many jobs wages may be only loosely related to current effort with longer-run goals important. We discuss this issue subsequently.

2. The Econometrics of Labor Supply with Taxes

The essential feature which distinguishes econometric models of labor supply with taxes from traditional demand models is the non-constancy of the net, after tax wage.[1] Except for the case of a proportional tax system, the net wage depends on hours worked because of the operation of the tax system. Also the marginal net wage depends on the specific budget segment that the individual's indifference curve is tangent to. Thus, econometric techniques need to be devised which can treat the nonlinearity of the budget set. However, it is important to note at the outset that a simultaneous equation problem does not really exist, even though the net wage received depends on hours worked. Given a market wage which is constant over hours worked and a tax system which is given exogenously by the government, the nonlinear budget set faced by the individual in deciding on his preferred hours of work is determined exogenously to his choice.[2] An econometric model needs to take the exogenous nonlinear budget set and to explain the individual choice of desired hours. We first describe such a model for convex and nonconvex budget sets. As expected, the convex case is simpler to deal with. We then consider other issues of model specification such as variation in tastes, fixed costs to working, and quantity constraints on available labor supply.

Econometric estimation is quite straightforward in the case of a convex budget set. Since a unique tangency or a corner solution at zero hours will determine desired hours of work, we need only determine where the tangency occurs. To do so we begin with a slight generalization of the usual type of labor supply specification

$$(2.1) \qquad h = \tilde{g}\,(w,\ y,\ z,\ \beta) + \varepsilon = h^{*} + \varepsilon$$

where w is a vector of net wages, y is a vector of virtual incomes, z are individual socioeconomic variables, β is the unknown vector of coefficients assumed fixed over the population, and ε is a stochastic term which represents the divergence between desired hours h* and actual hours. The typical specification that has been used in $\tilde{g}(\ )$ is linear or log linear and scalar w and y corresponding to the market wage and nonlabor income. The stochastic term is assumed to have classical properties so that no quantity constraints on hours worked exist. However, $0 \leq h \leq \bar{H}$ where H is a physical maximum to hours worked. We also assume that when the β's are estimated that the Slutsky conditions are satisfied so that $\tilde{g}(\ )$ arises from concave preferences.

The problem to be solved is to find h* when the individual is faced with the convex budget set, B_i for $i=1,\ldots,m.$[3] To find h* we take the specification of desired hours on a given budget segment B_i

$$h_i^* = g\ (w_i,\ y_i,\ z,\ \beta) \tag{2.2}$$

Calculate h_i^* and if $0 \leq h_i^* \leq H_i$ where the H_i's are kink point hours in figure 1.2 then h_i^* is feasible and represents the unique tangency of the indifference curves and the budget set. However, if h_i^* lies outside the interval $(0,\ H_i)$ it is not feasible so we move on to try the next budget segment. If $H_1 \leq h_2^* \leq H_2$ we again would have the unique optimum. If we have bracketed the kink point so that $h_1^* > H_1$ and $h_2^* < H_1$, then $h^* = H_1$ so that desired hours fall at the kink point. Otherwise we go on and calculate h_3^*. By trying out all the segments we will either find a tangency or find that $h_i^* < H_{i-1}$ for all i in which case $h^* = 0$ or $h_i^* > H_i^*$ for all i in which case $h^* = \bar{H}$. Then a nonlinear least squares procedure or Tobit procedure to take account of minimum hours at zero should be used to compute the unknown β parameters.[4] The statistical procedure would basicially minimize the sum of $\sum_{j=1}^{N} (h_j - h_j^*)^2$ where j represents individuals in the sample. Perhaps a better technique would be to use Tobit which enforces the constraint that $h_j \geq 0$.

The case of the nonconvex budget set as in Figure 1.5 or Figure 1.6 is more complicated because equation (2.2) can lead to more than one feasible tangency which leads to many potential h_i^*'s. How can we decide which of these feasible h_i^*'s is the global optimum? Burtless-Hausman (1978) initially demonstrated the technique of working backwards from the labor supply specification of equation (2.2) to the underlying preferences which can be represented by a utility function.[5] The basic idea to make use of Roy's identity which generated the labor supply function from the indirect utility function $v\ (w_i, y_i)$

$$(2.3) \qquad \frac{\partial v\ (w_i, y_i)}{\partial\ w_i} \Big/ \frac{\partial v\ (w_i, y_i)}{\partial\ y_i} = h_i^* = g\ (w_i, y_i, z, \beta)$$

along a given budget segment. So long as the Slutsky condition holds then $v\ (w_i, y_i)$ can always be recovered by solving the differential equation (2.3). In fact, v( ) often has a quite simple closed form for commonly used labor supply specifications. For instance for the log linear specification $h_i^* = k w_i^{\alpha} y_i^{\beta}$ where k is a function of z, Burtless-Hausman found the indirect utility function

$$(2.4) \qquad v\ (w_i, y_i) = k \frac{w_i^{1+\alpha}}{1+\alpha} + \frac{y^{1-\beta}}{1-\beta}$$

For the linear supply specification $h_i^* = \alpha w_i + \beta y_i + z\gamma$, Hausman (1979a) solved for the indirect utility function

$$(2.5) \qquad v(w_i, y_i) = e^{\beta w_i} \left(y + \frac{\alpha}{\beta} w_i - \frac{\alpha}{\beta^2} + \frac{z\gamma}{\beta}\right)$$

Given the indirect utility function, all of the feasible tangencies can be compared, and the tangency with highest utility is chosen as the preferred hours of work, h*.[6] Then as with the convex budget set case, we can use either nonlinear least squares or a Tobit procedure to estimate the unknown coefficients. While using a specific parameterization of the utility function seems upsetting to some people, it should be realized that writing down a labor supply function as in equation (2.2) is equivalent to writing down a utility function under the assumption of utility maximization. To the extent that the labor supply specification yields a robust approximation to the data, the associated utility function will also provide a good approximation to the underlying preferences. The utility function allows us to make the global comparisons to determine the preferred hours of labor supply. The convex case needs only local comparisons, but the nonconvex case requires global comparisons because of the possibility of multiple tangencies of indifference curves with the budget set.

We next introduce the possibility of variation in tastes. In the labor supply specification of equation (2.1), all individuals are assumed to have indentical β's so that the variation of observationally equivalent individuals must arise solely from ε. However, empirical studies seemed to do an inadequate job of explaining observed hours of work under the assumption of the representative individual. Greenberg and Kosters (1973) seemed to be the first paper that allowed for a dispersion of preferences to affect their model in an important way.[7] Burtless-Hausman (1978) allowed for variation in preferences by permitting β to be randomly distributed in the population. Their results indicated that variation in β seemed more important than variation in α.[8] They also found that variation in β represented approzimately 8 times as much of the unexplained variance as did variation in ε. An even more satisfactory procedure would be to allow all the taste coefficients to vary in the population. At present the requirement of evaluating multiple integrals over nonrectangular regions for the more general specification has led to use of the simple case of one or two taste coefficients varying. Further research is needed to determine whether this more complex specification would be an important improvement over current models.

Another consideration which can have an important effect on the budget set for women's labor force participation is fixed costs to working. Transportation costs, the presence of young children, and search costs of finding a job all can lead to a fixed cost element in the labor supply decision. The basic effect of fixed costs is to introduce a nonconvexity in the budget set at the origin. Thus, even if the original budget is convex as in Figure 1.2 the presence of fixed costs leads to a minimum number of hours H_0, which depends on the wage, below which an individual will not choose to work. In Figure 2.1 nonlabor income is y_1 with the

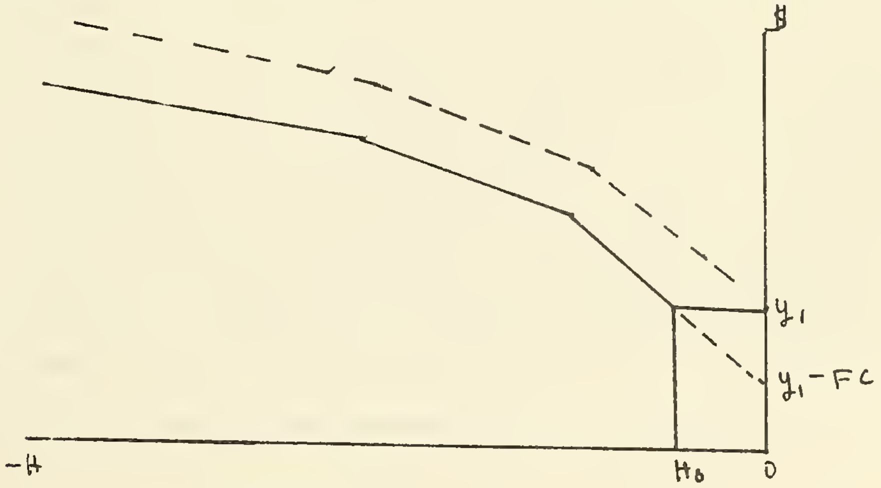

Figure 2.1

original convex budget set drawn by the dotted line. However, the presence of fixed costs lowers the effective budget set to the point y_1 - FC. The individual would not choose to work less then H_o hours because she would be better off at zero hours. This nonconvexity invalidates the simple reservation wage theory of labor force participation since hours also need to be accounted for. Hausman (1979a) in a labor force participation study of welfare mothers found average fixed costs to be on the order of $100 per month. The importance of fixed costs could explain the often noted empirical fact that very few individuals are observed working less than ten or fifteen hours per week.[9]

We now turn to the question of quantity constraints which seem to enter labor supply models in two possible ways. The first type of quantity constraint might arise if an individual has the choice of working either full time, say 40 hours per week, or not working at all. We can still estimate the parameters of his labor supply function by discrete choice models which allow a distribution of preferences, e.g., Hausman-Wise (1978), Smith (1979). For example, suppose we begin with the linear labor supply specification $h_i^* = \alpha w_i + \beta y_i + z\gamma$ along with the associated indirect utility function of equation (2.5). To compare indirect utility at zero and forty hours we need to specify w_i and y_i that would lead to the appropriate number of hours being chosen in an unconstrained setting.[10] But w_i and y_i can be solved for by using the desired hours supply equation and the linear equation through the point that gives net,after tax, earnings for that number of hours of work. For forty hours the equation is $E_{40} = w_i \cdot 40 + y_i$ where E_{40} arises from the budget set. We can solve the two equations in two unknowns for w_i and y_i and use the values for the required utility comparison so that α, β, and γ can be estimated. It turns out that this procedure is equivalent to solving for the direct utility function where only quantities appear so that quantity constraints enter in a straightforward manner. For instance, the direct utility function for our example is

$$(2.6) \qquad u\,(h,x) = \frac{1}{\beta}\left(h - \frac{\alpha}{\beta}\right) \exp\left[\left(-1-\gamma\left(x + \frac{z\gamma}{\beta} - \frac{\alpha}{\beta^2}\right)\right)\Big/\left(\frac{\alpha}{\beta} - h\right)\right]$$

where x is consumption of the composite commodity. However, the direct utility function need not exist in closed form in which case the previous solution procedure can be used with the indirect utility function. Of course, specification of a direct utility function could be done ab initio, but it might not be easily combined with the labor supply functions of unconstrained individuals.

The other type of quantity constraints which people seem to have in mind is the choice among jobs, each of which comes with a distinct market wage and hours of work combination. However, if the individual takes a given job he is constrained to work the given number of hours which come with the job. Again a discrete choice framework seems appropriate to model this situation. Use of either the indirect or direct utility function would allow the appropriate utility comparisons to be made. We would need to know the range of choices which a given individual faces. But the choice set might be either established by survey questions or estimated from a data set of choices of similar individuals. At this point we have strayed rather far from our original theory of flexible hours of work. In our empirical estimation we do not account for the possibility of quantity constraints. It seems unclear how important an empirical problem quantity constraints are. As we discuss later, even conditional on working in a given week the standard deviation of hours worked for prime age males is around 14 hours. Thus, the model of flexible labor supply with fixed costs may provide a reasonably good approximation, especially in the long run.

In this section we have demonstrated how the nonlinearity of the budget set which taxes create can be accounted for in an econometric model. The labor supply (leisure demand) curves are still the focus of model specification. For the convex budget set case the only new complication is to search for the budget segment on which h* falls. When the budget set is nonconvex, we need to solve for the indirect utility function which is associated with the labor supply specification. Then the multiple tangencies of the budget set and indifference curves can be compared to find the h* which corresponds to maximum utility. We also emphasized the potential importance of allowing for variation in preferences and fixed costs to working. Previous empirical studies indicate the potential importance of both considerations. Lastly, we discuss techniques to handle quantity constraints within the context of our approach. However, unless on a priori grounds you know who in the sample is quantity constrained, it is not clear that these procedures would be applied in a given sample.

NOTES

[1] Nonconstant prices do exist in the demand for other goods, e.g., electricity with a declining block rate. The situation is very similar to our analysis for the nonconvex budget set.

[2] If the market wage depends on hours worked the same reasoning holds since the budget set is still exogenous. We discussed this case in the last section.

[3] The technique used here is more fully explained in Hausman (1979b).

[4] A potential problem does exist in the asymtotic expansions used to compute the standard errors of the coefficients. However, my feeling is that the problem is not too serious for empirical work.

[5] Their work was done in the framework of labor supply and a composite consumption good. The technique can also be used in the many good case although it is more difficult to apply. Alternatively, one can begin with a utility function specification and derive the labor supply function as Wales-Woodland (1979) did.

[6] The indirect utility function can be used to evaluate tangencies on both budget segments and at kink points so that the direct utility function is unnecessary. As Figure 1.8 shows a tangency will not occur at a nonconvex kink point, but it may occur later on a convex portion of the budget set.

[7] For many linear regression specifications where the effect of taxes are not accounted for, variations in preferences leads only to an efficiency issue for the econometric estimator. However, taxes create an essential nonlinearity in the problem so that variation in preferences can be quite important. A similar issue arises in the specification of discrete choice models, e.g., Hausman-Wise (1978).

[8] It is interesting to note that Greenberg-Kosters had a similar type of variation in preferences. However, they did not allow for the effect of taxes so that the results cannot be compared.

[9] Since Hausman used only participation and not hours of work, his findings may reflect the labor supply decisions rather than reflecting a demand aspect of the market. Hanoch (1976) also found fixed costs to be an important component of a mode. of women's labor force participation but his model did not include the effect of taxes.

[10] Neary and Roberts (1980) and Deaton and Muellbauer (1980) discuss this technique in a general demand setting. However, they do not consider the effect of taxes.

3. Tax Systems

In the previous two sections we have discussed the theory of labor supply with taxes and the econometrics of labor supply with taxes. We will now describe the type of tax systems which exist in the United States. Since the sample used in our estimation procedure is from 1975, we will describe taxes as they existed in that year. However, any significant changes from 1975 up to the present will be identified. It is important to note that we do not have actual access to individual's tax returns. We therefore have to make certain assumptions about the type and amount of deductions they took. But since we exclude the very well off from our sample and all federal tax brackets but the first few were $4,000 wide for joint returns in 1975, the required assumptions may yield a close approximation to the actual case. Access to information on individual's tax returns such as adjusted gross income (AGI) would prove helpful to this type of exercise. We shall discuss federal and state income taxes first. It turns out that even though the basic federal income tax is progressive, the resulting budget set that an individual faces is not convex. FICA payments, the standard deduction, and the earned income credit all introduce nonconvexities. Next we discuss AFDC tax systems for each state. Lastly we briefly discuss tax systems for social security beneficiaries and negative income tax (NIT) recipients. Although we do not report new empirical results for these last two taxes, we will provide a review of existing findings so that it is worthwhile to discuss the form of the budget sets.

We represent the basic federal income tax system in 1975 by 12 brackets.[1] The first bracket is $1,000 wide with succeeding brackets falling at intervals of $4,000. Since we are interested in the effect of taxes on labor supply, we consider only taxes on earned income. Table 3.1 lists the brackets along with the marginal tax rates and average tax rates at the midpoint of the bracket. It is interesting to note that the average tax rate remains significantly below the marginal tax rate until quite high levels of earned income are reached. Thus a theory which stated that individuals react to average after tax income than making marginal decisions might come up with rather different results. However,

Table 3.1 Basic Federal Tax Rates on Earned Income for Married Couples[2]

Taxable Income	Marginal Rate	Average Rate at Midpoint
0-1,000	.14	.140
1,000-4,000	.16	.154
4,000-8,000	.19	.167
8,000-12,000	.22	.182
12,000-16,000	.25	.197
16,000-20,000	.28	.212
20,000-24,000	.32	.228
24,000-28,000	.36	.245
28,000-32,000	.39	.263
32,000-36,000	.42	.279
36,000-40,000	.45	.296
40,000-44,000	.48	.312
44,000+	.50	-

the theory of individual behavior contains both the marginal net wage and the appropriate virtual income which reflects average tax rates up to the current tax bracket. In a certain sense, the entire characteristics of the tax system are accounted for in this way.

For our sample we assumed that all married couples filed jointly. In forming the taxable income we took account of personal exemptions and assumed that individuals used the standard deduction up to the limit of $16,250. A nonconvexity is created here because the standard deduction depends on income. In 1975 for income below $11,875 the standard deduction was $1,900 but between $11,875 and $16,250 it was 16% of income. Thus at approximately $12,000 of taxable income the marginal tax rate falls to 84% of its previous value creating a nonconvexity since the net wage rises at this point. The standard deduction was used on approximately 2/3 of all tax returns in 1975. Beyond $20,000 we used the average of itemized deductions for joint returns for each tax bracket found in Statistics of Income. Next, the earned income credit reduces taxes by 10% below $4,000 of gross income. Because of personal exemptions and the standard deduction only FICA is being paid after the earned income credit is accounted for. From $4,000 to $8,000 it increases the tax by 10% so that the breakeven point is reached at $8,000 when the credit has been completely exhausted. A nonconvexity is created at $8,000 because the tax rate falls by the 10% payment when the breakeven point is reached. We also take account of FICA contributions which were 5.85% up to a limit of $14,000 for 1975.[3] Thus, in the appropriate bracket when the FICA limit is reached, the marginal tax rate falls from about .31 to about .25 which also creates a nonconvexity. For our empirical work we try out both the complete Federal tax system and also a 'convexified' version to see if the results are as sensitive to the exact nonconvex form of the budget set.

State income taxes (including the District of Columbia) were also added to the budget sets. In 1975 ten states did not tax earned income but the other 41 states have either progressive of proportional tax systems. Sixteen states permit deduction of federal income taxes. Among the states with progressive tax systems Delaware has the highest overall marginal tax rate of 19.8%. However, at $15,000 after personal exemptions the marginal rate in California is 10%, in Hawaii it is 10%, in Minnesota it is 14%, in New York state it is 10%, in Oregon the marginal tax rate is 10% above $15,000, and in Wisconsin the marginal rate is 11.4% at $15,000. Nebraska, Rhode Island and Vermont are the only states which take a constant percentage from the federal taxes paid. Rhode Island takes the highest proportion, 17%. Among states with proportional rates after personal exemptions Illinois has a rate of 2.5%, Massachusetts has a rate of 5.4% and Indiana and Pennsylvania have rates of 2%. In order not to have an inordinate number of tax brackets in the budget set for estimation purposes we match the state tax brackets up to the federal tax brackets and average the state tax rates within the federal tax brackets. Two possible problems exist in our procedure. First, we could not include city income or wage taxes due to a lack of exact residence or job location data. Also, a resident of one state who works in another may pay a higher rate, e.g., a New Hampshire resident which has no income tax pays Massachusetts state taxes on his Massachusetts earnings. Again, lack of data prevents the appropriate adjustments. It is unlikely that large errors arise from these approximations.

Beside the operation of the Federal tax system, another potentially more important influence on labor supply of female heads of household is the AFDC tax and transfer system. It has often been contended that AFDC presents a significant disincentive to labor supply, and its replacement by NIT could significantly decrease the work disincentive.[4] The basic design of AFDC programs is a transfer payment which depends on family size accompanied by a tax rate of 67% until the breakeven point is reached and the person returns to the federal tax system. A sizeable nonconvexity is created because at the breakeven point the marginal tax rate decreases from .67 to approximately .16. Thus, the potential disincentive effect is quite large. States differ in the size of the transfer payment and also in the exact operation of the AFDC tax system. The majority of the states permit $30 of earned income per month before starting to levy the .67 tax.[5] Thus, in Figure 3.1 we show the basic outline of the AFDC budget set. Breakeven hours $\tilde{H}$ may not be reached even by women who work

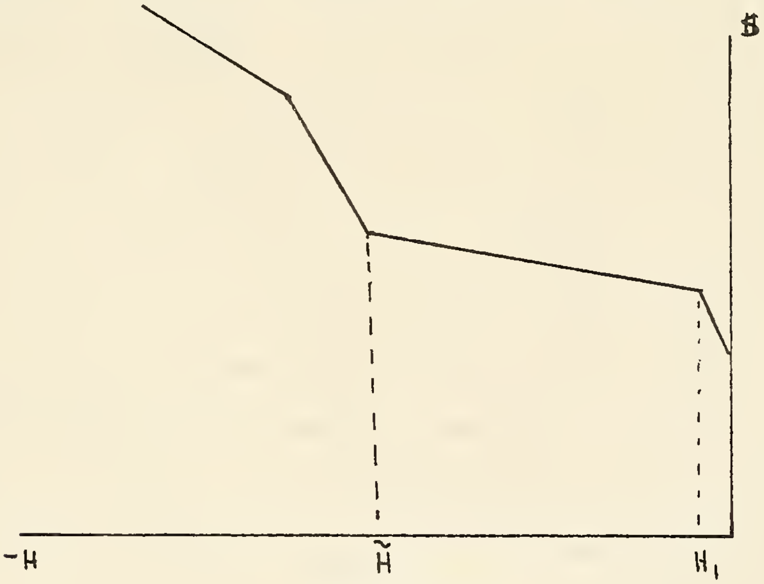

Figure 3.1

full time. For example, if the transfer payment is \$300 which is about the national mean for a three recipient family, for a forty hour week $\tilde{H}$ is reached only if the wage exceeds \$2.80/hour. Three states modify the basic diagram by establishing need standards. They reduce both the transfer payment amount and the marginal tax rate by a percentage amount ranging from .54 in South Carolina to .86 in New Mexico. Lastly, eight states have maximum payment amounts. Thus, they set a maximum payment of from 15% in Mississippi to near 100% in other states of the basic need level of the family.[6] Labor income does not then force the .67 tax rate until the need level is reached. The first kink point, H_1, in Figure 3.2 is where the .67 rate begins. For instance in Missouri the new level for a three recipient family is \$325 but the maximum payment is only \$120. Thus at a \$2.25 wage rate, H_1 equals about 90 hours per month. On this segment only Federal taxes would be paid.

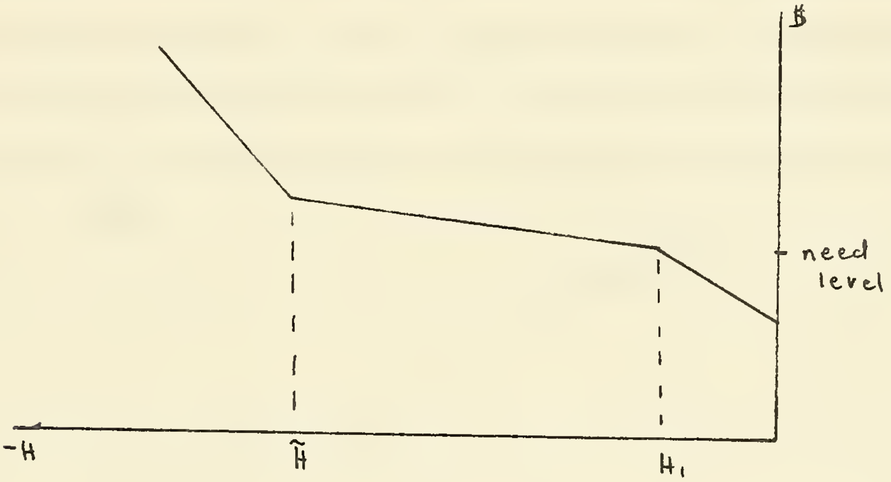

Figure 3.2

The workings of an NIT tax system resemble AFDC as in Figure 3.1 although no earnings disregard exists. Major differences are eligibility, since all families would qualify, and benefit and tax parameters. The NIT guarantee is a function of the poverty limit which depends on family size and the local cost of living. The guarantee has been set at between .75 and 1.25 times the poverty limit in the NIT experiments. For instance in Indiana .75 times the poverty limit was 28% higher than the AFDC payment for non-labor force participation for a family of four. Thus the NIT guarantee is typically more generous than the AFDC payment. The marginal tax rate up to breakeven hours is also lowered from .67 to a value between .4 and .6. Thus, the budget set has the nonconvex form of Figure 3.3 where beyond breakeven hours, $\tilde{H}$, the individual returns to the federal tax system. At breakeven hours the marginal tax rate falls from .4 and .7 to around .25 when federal taxes and FICA are accounted for. For male heads of households with good jobs on the less generous plans of a low guarantee and high tax rate, breakeven hours will be reached at about 120 hours per month of work. For males on very generous plans or those with low wages, breakeven costs will not

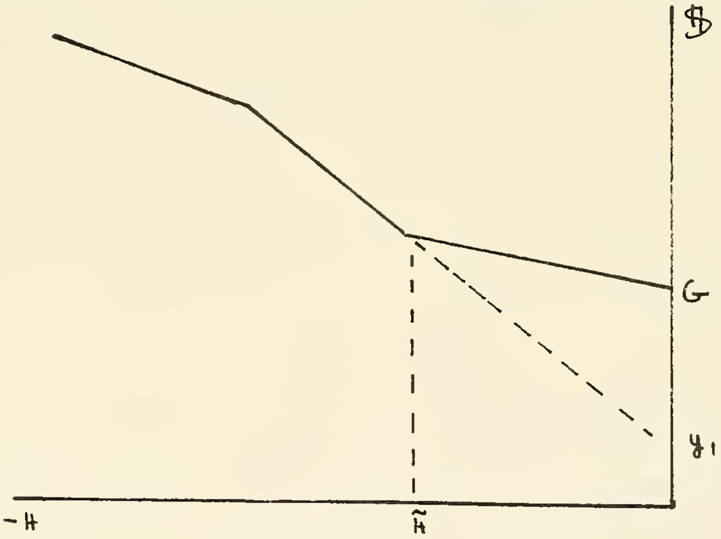

Figure 3.3

be reached even for high hours of work. Likewise, for female heads of household the majority will not reach breakeven hours because of their relatively low wages. Thus the position of the first tax segment and the nonconvexity created at $\tilde{H}$ hours may have a significant influence on labor supply decisions.

The last tax system we consider is the operation of the social security earnings test for individuals between 62 and 72 years old who are receiving social security benefits. The budget set has exactly the same form as the operation of AFDC in Figure 3.1. A level of benefits is received at zero hours which depends on past social security earnings and family composition. An 'earnings disregard' then exists up to an amount which determines H_1 hours.[7] Beyond H_1 hours earnings are taxed at a rate of .5 until breakeven hours $\tilde{H}$ are reached. Thus, we again seem to have a possibly large disincentive to working.[8] But, this diagram leaves out a potentially important effect which Blinder, Gordon, and Wise (1979) point out. The effect is that current earnings will replace lower previous earnings which are used to compute average monthly earnings which the benefit level is partly based on. Especially with the low levels of previous FICA amounts, current earnings could replace the $3,600 level in force from 1951-1954 and for about 20% of near retirement workers replace previous zero FICA earnings years. Thus, if individuals understand the admitedly extremely complex social security benefit formulas, the work disincentives can be greatly diminished. Blinder, Gordon, and Wise actually give an example where the earnings test is more than compensated for as a work incentive exists. Thus, empirical studies which use historical data may have great difficulty in adequately representing the correct budget set. The indexing provision of the 1977 Social Security Amendments greatly lowers the quantitative significance of earnings replacement. However, the disincentives effect of the earnings test is still diminished. The intertemporal aspects of the interaction of social security and the retirement decision probably require a more complex model than our essentially one period representation of the budget set. While the problem is quite difficult to represent in a model, social security may have a significant effect on retirement. The quantitative magnitude may be large especially as the effect of the new retirement provisions begins to take hold.

In this section we have discussed the effect of Federal and state tax systems on the budget set. While federal tax rates are uniformly progressive, nonconvexities still exist in the budget set due to the presence of the standard deduction, earned income credit, and FICA contributions. State income tax and AFDC programs are also discussed. Next the NIT tax system and its relation to AFDC is considered. Lastly, the budget set for the social security earnings test and the complex intertemporal aspects of retirement are outlined. In this last area further work seems required to extend the labor supply model to account for intertemporal decisions.

NOTES

[1] Here we discuss our procedure for joint returns. We followed similar procedures for single persons and heads of households but do not report the details here.

[2] These brackets are exactly according to the IRS code except for the $1,000-4,000 bracket where we averaged the three $1,000 brackets into a single $3,000 wide bracket.

[3] Additional tax brackets are added to Table 3.1 in the empirical section to account for the effort of the standard deduction, earned income credit, and FICA contributions. Both the percentage tax and limit for FICA have risen markedly since 1975.

[4] However, for a sample in Gary, Hausman (1979a) finds the income effect to overwhelm the substitution effect so that black women on the NIT are less likely to work than women on AFDC.

[5] However, if fixed costs to working are important, this $30 exemption will have only a minor effect on labor supply.

[6] The incredibly low level of AFDC in Mississippi is well known but certainly deserves mention. Maximum payments for families of 2, 3, and 4 recipients were $30, $40, and $68 respectively in 1975.

[7] The earnings disregard level is currently $250 per month.

[8] If the individual is eligible to receive benefits but continues working without receiving benefits, his future benefits are increased by an approximately actuarily fair amount.

4. Estimation Results

We estimate a model of labor supply which takes full account of the effort of taxation for three groups in the population. The labor supply of husbands, wives, and female heads is considered for 1975 for a sample from the Michigan Income Dynamics Data.[1] Other population groups such as unmarried male heads could not be estimated due to lack of data. At the current stage of model development only a single person can be considered so that the husband was tested as the primary worker in a family with the wife as the secondary worker. This assumption has been made by all previous empirical research which attempted to account for the effect of taxes.[2] Thus, our results can be compared to the findings of previous research. Still, a model which allows for joint family labor supply decisions seems the obvious next goal of our research. For both husbands and wives we consider each of two cases: a convex budget set where the effects of FICA, the earned income credit, and the standard deduction are averaged to produce a convex budget set and a complete nonconvex budget set where the effect of each program is to introduce a nonconvexity. Since the convex case is considerably more simple, it is interesting to know is the results differ much in the convex and non-convex cases. For female heads we consider only the non-convex case since the presence of AFDC introduces a large initial non-convexity as Figures 3.1 and 3.2 indicate. The model allows for zero hours of work, a distribution of preferences in the population, and fixed costs to working. Thus, all of the considerations of Section 2 are treated except for the possibility of quantity constraints in the amount of hours worked. We first present the econometric specification of the labor supply model and then discuss the results for each of the three groups.

Along each segment the basic labor supply model which is used is linear in the wage and virtual income

$$(4.1) \qquad h_i^* = \alpha w_i + \beta y_i + z\gamma$$

where h_i^* is desired hours, w_i is the net wage on segment i, y_i is virtual income for segment i, and z are socioeconomic variables. For fixed α, β, and γ desired hours h_i^* may not be feasible since h_i^* may be greater than or less than the hours at the end points of the budget segment H_{i-1} and H_i. If desired hours are feasible then we have a tangency of the indifference curve and the budget segment. In the case of a convex budget set this tangency is unique, and we then use our stochastic specification for the deviation of actual hours from desired hours for person j as

$$(4.2) \qquad h_j = h_{ij}^* + \eta_j$$

Since observed hours $h_j \geq 0$ the stochastic term η_j is assumed to be independent truncated normal across individuals in the population. Thus, we have a Tobit specification for the hours worked variable. However, if $h_j^* = 0$ we assume that the individuals do not choose to work and so set $h_j = 0$ also. Since the final model has two sources of stochastic variation the interpretation of η_j differs from standard models. Here we picture the individual faced by a choice from a set of jobs which differ in normal (long run) hours worked. He chooses that job closest to his h_j^*. But observed h_j may differ due to unexpected layoffs, short time, overtime, or poor health. As an empirical matter we find the standard deviation of η_j to be reasonably small which indicates that individuals are successful in matching jobs to their desired hours of work.

If the budget set is non-convex h_i^* is not necessarily unique because multiple tangencies can occur between the indifference curves and the budget set. Then h_{ij}^* is chosen as the tangency which leads to maximum utility which is determined by use of the corresponding indirect utility function from equation (2.5) . We again use the stochastic specification of equation (4.2) to express the deviation of actual hours from desired hours of work. It is interesting to note that although certain kink points such as H in Figure 1.5 in the non-convex case cannot correspond to desired hours, we might still observe them as actual hours or work due to the stochastic term η_j in the model.[3]

The second source of stochastic variation in the model arises from a distribution of tastes in the population. In line with our previous research we specify β to be a truncated normal random variable which falls in the internal $(-\infty,0)$.[4] An upper limit of zero is specified since we assume that leisure is a normal good. Thus, as β ranges over the permissable interval there is a certain probability that any amount of hours corresponds to desired hours. As an empirical matter β turns out to be the major source of stochastic variation in the model which confirms our previous findings reported in Burtless-Hausman (1978).

To develop the appropriate likelihood function we first note that any budget segment can be described by a sum over budget segments and kink points. For each budget segment or kink point we determine the range of β which will lead to the desired hours falling on that budget segment or at the kink. First, consider those individuals with observed hours of work equal to zero. An individual works zero hours either because his β is so negative that $h^* = 0$ or because η_j was negative in equation (4.1) to cause $h_j = 0$ even though $h_j^* > 0$. Therefore, the probability of zero hours is[5]

$$(4.3) \qquad \mathrm{pr}\ (h_j = 0) = \int_{-\infty}^{\beta_j^*} f(\beta)\, d\beta + \sum_{i=1}^{m} \left[\int_{\beta_{i-1,j}}^{\beta_{ij}} \int_{\infty}^{q_{ij}} f(\beta) f(v_{ij}) dv_{ij}\, d\beta \right]$$

$$+ \sum_{i=1}^{m-1} \left[\int_{\infty}^{q_{ij}} (F(\beta_{ij}) - F(\beta_{i-1,j})) f(v_{ij}) dv_{ij} \right]$$

β_j^* is the minimum β which causes desired hours to be positive for person j so that the first terms in equation (4.3) correspond to zero desired hours. The middle term is the probability that desired hours falls along one of the m budget segments but that the stochastic term η_j is so negative that actual hours are zero. Here $v_{ij} = \eta_j + \beta y_{ij}$ so that v_{ij} is distributed normally as $N(\bar{\beta} y_{ij}, \sigma_\beta^2 y_{ij}^2 + \sigma_\eta^2)$ and $q_{ij} = -\alpha w_{ij} - z_j \gamma$. The joint probability density of this term is bivariate normal. The last term in equation (4.3) corresponds to desired hours falling at one of the m-1 kink points but actual hours are zero due to η_j. For those individuals observed to be working the probability of actual hours of work is similar but somewhat more simple since the first term is absent and only univariate probability densities are required since truncation of hours worked does not take place. Thus, the probability that individual j works h_j hours is

$$(4.4)\qquad pr(h_j) = \sum_{i=1}^{m} \left[\int_{\beta_{i-1,j}}^{\beta_{ij}} f(h_j - h^*_{ij})\, f(\beta)\, d\beta \right] + \sum_{i=1}^{m-1} \left[\left(F(\beta_{ij}) - F(\beta_{i-1,j}) \right) f(h_j - h^*_{ij}) \right]$$

As before the first term corresponds to the budget segments while the second term corresponds to kink points so that h^*_{ij} corresponds to kink hours H_{ij}. Then over the n sample observations the log likelihood function takes the form

$$(4.5)\quad L(\alpha, \beta, \gamma, \sigma^2_\beta, \sigma^2_\eta) = \sum_{j=1}^{n} \left[(1-D_j) \log (pr(h_j=0)) + D_j \log(pr(h_j)) \right]$$

where D_j is an indicator variable with $D_j = 0$ if individual j doesn't work and $D_j = 1$ otherwise. The parameters are estimated by maximum likelihood techniques using the Berndt, et.al. (1974) algorithm. Starting values were obtained by instrumental variable estimation.

A. Husbands Results

A sample of 1085 married men was constructed from the non-SEO part of the Michigan Income Dynamics (PSID) data for 1975. The sample is restricted to prime age males from 25 to 55 years of age. Farmers, self-employed individuals, and those individuals suffering from a severe disability were excluded from the sample. Annual hours of work was chosen as the dependent variable in accord with our interpretation of h^*_{ij} and our treatment of taxation. Approximately .5% of the sample worked zero hours in 1975. Non-labor income was formed by attributing an 8% return to financial assets while house equity is treated as a separate variable due to its special untaxed character.[5a] Age is treated by including a variable for years over 45. The bad health variable is in response to a survey question. Taxes were calculated according to the conventions presented in Section 3 with both federal and state taxes accounted for.

The estimated results for husbands are presented along with asymptotic standard errors. The coefficients are generally estimated quite precisely, especially the wage and non-labor income coefficients. The socioeconomic variables have coefficients of reasonable magnitude except the house equity which perhaps reflects factors in the mortgage credit market and the special tax treatment of houses. We first note that the uncompensated wage coefficient is essentially zero. Not only is the estimate close to zero but the estimated standard error is quite small. In the extreme case of two standard deviations from the estimate for the nonconvex case, a change in the net wage of $1.00 along a budget segment leads to an expected increase in annual hours worked of 32.5 which is less than 2% of the sample mean. The expected change in hours is only 11.3 while in the convex case the expected change in annual hours is .2. The finding of an extremely small uncompensated wage effect is in accord with the

TABLE 4.1 HUSBANDS ANNUAL HOURS OF WORK (THOUSANDS)*

Variable	Convex	Nonconvex
1. μ_β - Non-labor income (1000's)	2.037 (.0729)	1.061 (.245)
2. σ_β	.6242 (.0234)	.4541 (.0570)
3. Wage	.0002 (.0090)	.0113 (.0106)
4. Constant	2.4195 (.0589)	2.366 (.153)
5. Children under 6	-.0039 (.0255)	.0113 (.0635)
6. Family size	.0341 (.0170)	.0657 (.0310)
7. (Age -45, 0)	-.0011 (.0108)	-.0055 (.0235)
8. House equity (1000's)	.0026 (.0009)	.0036 (.0008)
9. Bad Health	-.1387 (.1436)	-.0520 (.564)
10. σ_η	.2794 (.0178)	.2862 (.0540)
11. Mean β	-.166	-.153
12. Standard Deviation of β	.156	.141
13. Median of β	-.120	-.113

* Asymptotic standard error are presented below each estimated coefficient.

previous empirical findings. Thus the direct effect of income taxation which reduces the net wage has almost no effect on hours worked among husbands.

However, our results do differ from previous studies in indicating a significant income effect. Remember that we allow a distribution of preferences in the population. The estimated probability density for the nonconvex case is shown in Figure 4.1. The distribution has substantial skewness since it is the extreme left tail of the truncated normal distribution with the standard deviation approximately equal to the mean in magnitude. This finding is repeated in the convex case with the skewness even more pronounced. My previous work has also found this general form even when different probability densities are used, e.g., Hausman (1979a) where a Weibull density is used. The underlying parameters of the preference distribution are estimated quite precisely so that the finding is not likely to be an accidential occurence. To interpret the result let us consider an individual in the $8,000-$12,000

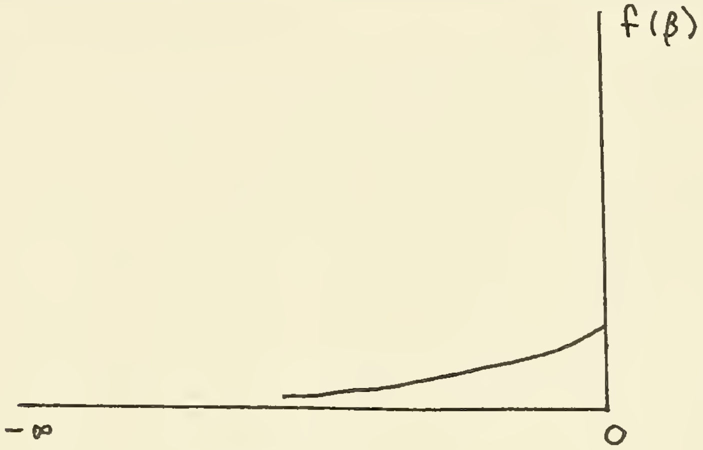

Figure 4.1

federal tax bracket. In the nonconvex case due to the indirect effect of taxation we calculate that the mean individual (with mean preferences) works 187.6 hours less than he would choose to work in the no tax case. Thus, we find a decrease in desired hours of work to be 8.2% on account of taxation of labor earnings.[6] The effect of taxation does change the hours worked decision in an important way. Our estimates indicate that taxation may have real effects due to the income effect that we estimated.

We now consider whether progressivity of taxation may be leading to substantial deadweight loss due to the tax induced distortion. Since our findings indicate that the substitution effect is approximately of equal magnitude but opposite sign of the income effect, welfare loss may be substantial. To find the approximate size of the distortion we calculate the exact deadweight loss for the individual in the sample at two different mean market wage levels, the mean wage of $6.18 per hour and $10 per hour. We define the deadweight loss as the excess of the consumers durplus over the tax revenues collected and use the compensating variation to measure the consumers surplus. To calculate consumers surplus we derive the expenditure function which corresponds to the indirect utility function of equation (2.5). Thus, the estimate of consumers surplus is exact given the estimated parameter values so that our estimate of deadweight loss is accurate. Hausman (1979c) demonstrates that use of the Marshallian approximation to deadweight loss may be quite inaccurate.[7] For the deadweight loss calculations we take account only of the federal tax system and neglect state income taxes. Foe the mean individual who earns $6.18 per hour we find the deadweight loss to be $234 which is 4.6% of his net income and 21.8% of tax revenues collected from him. To see the effect of the progressivity of the income tax, we repeat the calculations for the mean individual who earns $10 per hour. The deadweight loss now rises to $2995 which is 19.2% of net income or 71% of tax revenues. An interesting calculation might then be to compare the deadweight loss to an equal yield proportional tax for the given individual. For the 6.18 per hour individual deadweight loss for a proportional tax is $129 or 59.5% less than for the progressive tax case. For the $10 per hour individual deadweight loss for a proportional tax is $1270 which is 85.8% less than for the progressive tax. Of course, these calculations overstate the difference between the two types of tax systems since a proportional tax would have an identical tax rate for all individuals. Nevertheless, the calculations do indicate that taxation induces a substantial deadweight loss even for males, and that the welfare cost of a progressive tax system is not negligible.

The finding of a significant income effect and concomitant welfare cost for male heads of households is contrary to the received knowledge in the field, e.g., Pechman (1976). But the finding only appears when the progressivity of the income tax is accounted for. Since most previous studies did not attempt to model the tax system, their estimates might be interpreted 'as if' a proportional tax system existed so that they could not find the income effect found here.[8] To the extent that our findings are substantiated in future research, the previous presumption that the efficiency effect and welfare effect of a progressive tax system are quite small or zero needs to be revised.

B. Wives Results

Next we consider the empirical results for a sample of married women. Our sample consists of the wives of the males used in the previous section. Previous research has indicated that married womens' labor supply decisions are sensitive to the net wage so that we would expect to find that taxes create both an important uncompensated wage effect and an income effect as they do for husbands. As we previously stated, we treat wives labor supply decisions conditional on husband's earned income. Thus, wives are considered to be secondary workers which may not be a proper assumption. Since in our sample labor force participation of husbands is near 100% while wives is near 50% perhaps treating wives earnings conditional on husbands earnings is not a particularly bad assumption. However, the crucial question is whether husbands earnings should enter the wives labor supply decision as exogenous non-labor income. It is probable that some jointness in decision making takes place when the husband adjusts his hours of work to his wife's earnings. A family labor supply model would be able to treat these problems better, but here we only provide estimates for the conditional model.

In Section 2 we considered the problem of whether the market wage might depend on hours worked. There we demonstrated that if a piecewise linear representation of the market wage-hours locus were sufficient, then no special econometric problems would arise. A non-constant market wage would simply lead to further nonlinearities of the budget set in addition to the nonlinearities which taxes create. Since many wives are 'part-time' workers, we decided to investigate the possibility of a market-wage hours locus in our sample. Various specifications were tried where hours entered as a regressor for the market wage equation, either in piecewise linear form or as a polynomial.[8a] An instrumental variable procedure was used to estimate the coefficients since hours are an endogenous variable. For Table 4.2 we present some of the results for the market wage equations where log of the market wage is the left hand side variable, Other variables used as regressors are tenure with employer, tenure in position, race, union status, education, and college graduation. We do not present the estimated coefficients for these variables since our main focus is on the market wage and hours relationship. The results in Table 4.2 find no significant market wage-hours locus. Every asymptotic standard error exceeds the

Table 4.2: Log Wage Regression - Sample Size 574

Variable	OLS	Linear	Polynomial	Piecewise Linear
1. Hours	-	.00353 (.00459)	.0768 (.0869)	
2. Hours^2			-.00160 (.00173)	
3. Hours from 0-20				.00456 (.01964)
4. Hours from 20-35 minus 20				-.00689 (.0313)
5. Hours from 35 up minus 35				.0108 (.0569)
Standard error	.348	.343	.328	.384
R^2	.3316	-	-	-

size of the estimated coefficient. Furthermore, the empirical magnitudes are not especially large. For instance the linear relationship predicts that a 35 hour worker's wage would be 5.3% higher than the market wage for a twenty hour worker. At the mean of the sample this difference corresponds to about 20¢ per hour. When we turn to the polynomial regression presented in the third column, we find that the wage difference which corresponds to going from a 20 hour week to a thirty five hour week is about 4% so that again no important difference is found. Lastly, the piecewise linear regression also does not find evidence of a wage hour locus although the coefficients are very imprecisely estimated. We conclude that for our sample of working wives little or no evidence is found for a market wage-hours relationship.[9] Thus, we use a constant market wage in our labor supply estimates.

The next problem that needs to be resolved is how to predict the market wage for that part of the sample which does not work. Use of the least squares forecast for market wage may be improper due to sample selection bias as first pointed out by Groneau (1973). We thus use a missing data approach where we jointly fit a wage equation and a probit equation for labor force participation.[10] The finding of significant correlation between the stochastic distribances of the two equations would indicate that sample selection bias is present. Our estimate of this correlation is quite small, .132, with an asymptotic standard error of .182. Furthermore, the estimated coefficients of the wage equation are virtually identical to the coefficients estimated from least squares on the subsample of working women. Thus, we find no evidence of sample selection bias whatsoever. These findings agree with previous studies when the sample selection estimation is done correctly.

We now turn to the estimates of the labor supply equations which are presented in Table 4.3. We present estimates for a convexified budget set, for the complete nonconvex budget set, and for a nonconvex budget set with fixed costs included. First note that we find substantial uncompensated wage and income elasticities. For the average woman who is working full time we find the uncompensated wage elasticity to be .995 for the nonconvex results and a similar magnitude for the convex results, .978, is found.[11] When fixed costs are added the uncompensated wage elasticity falls to .9065. Thus, all three estimates indicate that the effect of the income tax in decreasing the after tax, net wage is important in determining wives labor supply. Since wives net wage is lowered substantially by the presence of the 'marriage tax', the tax effect may be much greater than if wives earnings were not added to husbands earnings for tax purposes. Perhaps the major result for the nonlabor income variable is the extreme skewness of the distribution. For instance, in the nonconvex case with fixed costs the mean is -.6805 while the median is -.1896. Similar results are found in the convex case and nonconvex case, although the nonconvex results show less effect of nonlabor income since approximately 50% of the wives work while nearly all of their husbands are employed full time. Here the effect of the income tax is to cause wives to work more than they would otherwise decide to because their husbands earnings are reduced by taxes as well as the wives virtual income. However, it is important to realize that while the tax effect on the net wage and the tax effect on nonlabor and virtual income have opposite signs, the deadweight loss of the two effects do not offset each other. Instead their effect is cumulative in determining the compensated wage effect which

Table 4.3 Wives Annual Hours (Thousands)

Variables	Convex	Non-Convex	Non-Convex with Fixed Costs
1. μ_β- Income (1,000's)	2.0958 (.1389)	1.7519 (.1475)	2.0216 (.1186)
2. σ_β	.5390 (.0460)	.4836 (.0490)	.5262 (.0711)
3. α - Wage	.4951 (.2310)	.5058 (.0932)	.4608 (.1062)
4. Intercept	.5790 (.9517)	.3501 (.4907)	.6234 (.5766)
5. Family Size	.2387 (.1270)	.2202 (.0773)	.2144 (.1259)
6. Children < 6	-.1695 (.3426)	-.1123 (.2239)	.1472 (.1576)
7. College Education	-.7851 (.4216)	-.7205 (.2390)	-.6903 (.4389)
8. Age (35-45)	.2328 (.1102)	.0733 (.0349)	.0824 (.0436)
9. Age (45+)	-.1066 (.0644)	-.1043 (.0539)	-.1989 (.0660)
10. Health	-.4771 (.7274)	-.3139 (.4753)	-.3581 (.4647)
11. Equity	-.0221 (.0172)	-.0150 (.0039)	-.0210 (.0113)
12. Fixed Costs-Intercept	- -	- -	1.2125 (.3570)
13. Fixed Costs-Kids < 6	- -	- -	.1720 (.9541)
14. Fixed Costs-Family Size	- -	- -	-.2118 (1.6106)
15. σ_η	.3086 (.2388)	.2907 (.2099)	.2801 (.2386)
16. Mean of β	-.125	-.118	-.123
17. Standard deviation of β	.112	.109	.113
18. Median of β	-.089	-.085	-.088

creates the deadweight loss from taxation. We now do some representative calculations to determine the size of the deadweight loss.[12]

In our calculation of deadweight loss we take the demographic characteristics of the average woman but use the median of the estimated income coefficient since the median will represent the midpoint of the population dispersion. We suppose that the wife's husbands pre-tax earnings are $10,000 and that her market wage is $4 per hour. We consider the case where she works full time. After deductions her federal marginal tax rate is approximately .28. Federal income taxes on her earnings are $2080. Deadweight loss is calculated to be $1208 which is 58.1% of tax revenue. Thus, the effect of the tax treatment of married individuals is to create substantial deadweight loss for working wives. It is difficult to decide on an appropriate comparison for an altered tax system. The choice used here is to treat the wife as a single individual without use of the earned income credit, standard deductions, or exemptions which her husband has taken advantage of. Federal taxes on earnings fall from $2080 to $1250which is a decrease of 50.9%. However, deadweight loss falls from $1208 to $731 which is a decrease of 50.2%. Thus, while deadweight loss does fall when the tax treatment if changed from married rates to single rates the ratio of deadweight loss to total taxes raised stays approximately constant. The appropriate policy question would be to decide whether other tax proposals, such as a proportional tax, would decrease the deadweight loss to tax revenue ratio of approximately 58%. The last comparison we make is to take utility at single tax rates as the basis of comparison. A change to married tax rates incurs a deadweight loss of $517. Since the difference in tax revenue raised in the two cases is $830, we find that the ratio of deadweight loss to the difference in tax revenue is 62%. This last comparison is probably most appropriate because it demonstrates the large cost in economic efficiency of moving from one tax system to another. Each extra dollar raised in tax revenue is accompanied by approximately 2/3 dollar lost as excess burden.

C. Female Heads Results

The last set of empirical results which we report is a labor supply model for prime age female heads of household with children under 18 present at home. Our sample consists of 119 females.[13] Thus, in principle each of the sample individuals qualifies for AFDC payments so that we construct budget sets for each individual which reflects her individual state's welfare provisions as we discussed in Section 3. It is important to remember that the marginal tax rate up to the breakeven point is .67 and that the states vary widely in the generosity of their basic allowance for a given family size. Of the 119 women, 22 did not work at all in 1975. Of the 97 women who did work, 16 women worked 1000 hours or less while 6 women worked less than 500 hours. Significant dispersion in hours existed among women who worked greater than 1000 hours. We estimate only the nonconvex labor supply model with fixed costs to working since the AFDC tax and transfer system introduces a very large nonconvexity into the budget set. Fixed costs turn out to be an important element of the model as they did for the wives results and in the labor force participation model of Hausman (1979a).

Before presenting the results we should mention that as for wives we tested the hypothesis that wages might be affected by hours worked. As before we could find little or no evidence in favor of this hypothesis. Nor did we find any significant evidence of sample selection in the wage equation used to predict wages for the 22 women who did not report a wage in 1975. The least squares results for the wage equation are virtually identical to the maximum likelihood results when the possibility of sample selection is allowed for.

The results for the female heads labor supply are given in Table 4.4. We find significant effects from the tax and transfer system both through its effect on non-labor income and through its effect on lowering the net wage below the market wage. For the mean woman working full time who is beyond breakeven hours the uncompensated wage elasticity equals .5264. The mean woman working 1000 hours who is below breakeven and facing the .67 marginal tax rate has an uncompensated wage elasticity of .4632. These wage elasticities are significantly higher than Hausman (1979a) found in his study of black female headed households for the Gary NIT sample.[14] The wage elasticities are about 1/2 as large as the wives wage elasticities and considerably larger than the husbands wage elasticities. This finding seems sensible since many wives may be secondary earners while husbands do not have AFDC or another program which would permit significant withdrawal from the labor force. On the other hand the mean β for the effect of nonlabor income is quite close to the nonconvex results for husbands. Here the mean is -.122 with a median of -.086 so significant skewness in the distribution of preference exists. However, the standard deviation of the distribution is about twice as large as for husbands.

We do not make deadweight loss calculations in the no tax case for this part of the sample since the no tax and transfer world is difficult to envision for AFDC recipients. Instead we consider possible effects on a woman whose market wage is $3.00 per hour and who is below breakeven so that she faces the .67 marginal tax rate. If the marginal tax rate were lowered to .50, she would be expected to work 178.9 additional hours per year. Tax revenue would fall by $344 is she were initially working

Table 4.4 Female Heads Annual Hours (Thousands)

1. μ_β - Income (1,000's)	2.0617 (.1154)
2. σ_β	.5359 (.0448)
3. α - Wage	.3509 (.0249)
4. Intercept	.4557 (.0825)
5. Family Size	.1753 (.0395)
6. Children < 6	.2500 (.0839)
7. College Education	.2848 (.1559)
8. Age (35-45)	.1138 (.0470)
9. Age (45+)	-.1912 (.1160)
10. Health	-.1202 (.0510)
11. Equity	-.0194 (.0130)
12. Fixed Costs-Intercept	1.3449 (.3857)
13. Fixed Costs - Kids < 6	.6596 (.3224)
14. Fixed Costs - Family Size	-.6544 (.1254)
15. σ_η	.419 (.0943)
16. Mean of β	-.122
17. Standard Deviation of β	.106
18. Median of β	-.086

1200 hours per year. On the other hand, her consumers surplus would be a gain of $707. Therefore after subtracting off the loss in tax revenues of $344 we find a decrease in the excess burden of $363. Note at the same time that this tax change would not effect most women working full time since they are beyond breakeven and would continue to do so after the tax change. Here again we have found a significant effect from the tax system. The tradeoff between a decrease in tax revenue versus the gain in consumers' surplus is difficult to evaluate without a full scale simulation of changes in the AFDC system. But we can confidently conclude that wage elasticities are not so large that reductions in the marginal tax rate of the magnitude commonly considered will call forth enough labor so that the AFDC budget would not increase. Reductions in the AFDC tax rate would require AFDC budget increases but would be counterbalanced by gains in consumer surplus which might well be significantly larger. Thus, a real tradeoff exists in considering reform of AFDC tax rates as well as income guarantees. Beyond breakeven the progressive nature of the tax system entails deadweight loss of the same order of magnitude as for husbands. Again a switch to a proportional tax brings the advantage of significantly lower deadweight loss. We do not present explicit calculations since the results are similar.

D. Directions for Tax Reform

The efficiency and welfare calculations that we have made in the previous sections have been for the mean individual in each group. Given the estimated distribution of preferences in the population and the nonlinearity of the progressive tax system, it is not clear how accurate these calculations are for the entire sample. Thus, in considering tax reform proposals we do a sample simulation over our sample of approximately 1000 husbands to assess the effects of tax reform.[15] We neglect state taxes in these simulations and only consider the effect of changes in the federal tax system.

We first compare the current tax system with a no tax world and calculate the hours of work effects, welfare effects, and distributional effects of the current progressive tax. Doing a simulation over the sample of husbands indicates that the tax system leads to a reduction in desired hours of work. The average reduction in desired hours is 197.5 hours per year. This reduction is 8.6% of total desired hours which again indicates an important hours of work effect caused by the income tax. To calculate the welfare loss we use the exact equivalent variation corresponding to our desired hours of work supply function. We use the equivalent variation rather than the compensating variation since for tax reform purposes we want to take the current situation as the basis for comparison. The average expected deadweight loss in the sample is $634 which is 42.1% of tax revenues raised.[16]

To measure the sensitivity of this calculation we find the elasticity of utility tax revenues raised to be 2.99. Thus small changes in the tax system can lead to significant changes in individuals welfare.

Next, we consider the distributional aspects of the current tax system. Table 4.5 gives the distribution of market wages and mean deadweight loss in each of five quintiles of the sample.

Table 4.5 - Market Wage and Deadweight Loss

Quintile	1	2	3	4	5
Wage	2.25-4.23	4.23-5.45	5.45-6.30	6.30-7.58	7.58-
Mean DWL	$78	$217	$362	$498	$1032

We see that as expected the DWL rises sharply with the market wage. For instance comparing the second and fourth quintile we found that while mean wages in the category differ by 36.4% that mean deadweight loss differs by 83.1%. A more than proportional rise in deadweight loss is the expected result of a progressive income tax, but the extremely rapid rise may be a reason for tax reform. We cannot say what the correct rate of rise might be in a progressive tax system, but our calculations indicate that individuals with higher wages are bearing a large proportion of the excess burden of the tax.

We now consider various equal revenue proportional taxes to calculate what the change in deadweight loss would be. We held total taxes constant and consider the equivalent variation as the appropriate measure for deadweight loss. A straightforward proportional tax with non-labor income being taxed at the same rate and no personal exemptions would need a rate of 14.6% to raise revenue equal to the current progressive tax system in our sample. The effect of such a tax would be to reduce desired hours of work 27.5 hours per year from the no tax case. This reduction is 197% less than the desired reduction from the current tax system. The average deadweight loss over taxes collected in the sample from such a tax is 7.1%. Thus, the reduction in deadweight loss from the current tax system is estimated to be 178%. Lastly, we consider making the proportional tax progressive by allowing for an initial exemption from taxes of labor income. The results are presented in Table 4.6. The first two columns give the exemption level and the marginal tax rate to raise the same amount of revenue as the current tax system. Note that the third column indicates that the change in hours from a no tax system remains small while the fourth column shows that deadweight loss over taxes begins to rise rapidly as the tax rate increases. Still, our welfare measure remains significant below the current tax system by about 107% even with a $4000 exemption. Lastly, note that a proportional tax with an initial exemption leads to a good deal of progressivity at low levels of earnings but that the increase in the average tax rate slows considerably by the point of mean earnings in the sample. These results might be expected to lead to a sharp reduction in deadweight loss since as a very rough approximation we know that excess burden rises with the square of the tax rate.

We have used our structural model of labor supply to consider the effect of possible tax reform. Most of our findings arise from the fact that we find a significant compensated substitution effect present in individuals labor supply decisions. Thus tax reform proposals which lower the marginal tax rate may lead to substantial decreases in deadweight loss which arise from income taxation. Our estimate further indicates that

Table 4.6 Effects of a Proportional Tax with Initial Exemption

Exemption level	Tax Rate	Changes in Hours	DWL/Taxes	Average tax rate at 4000	8000	16,000	24,000
1000	15.4%	- 28.2	.083	.116	.135	.144	.148
2000	16.9%	- 29.9	.098	.085	.127	.148	.155
4000	20.7%	- 34.5	.145	0	.104	.155	.172

desired hours of work would increase by between 5-10% from a change in taxation. Distributional issues become very important in assessing these proposals, but our results indicate that use of the income tax system as a means of redistribution may be a costly way to pursue these goals. Other more cost effective means of income redistribution may well exist.

NOTES

[1] We used the non-SEO part of the sample so as not to overweight low income earners. Specific sample considerations will be discussed when the results for each group are presented.

[2] Ashenfelter-Heckman (1976) consider a joint family labor supply but do not attempt to account for the effect of taxation.

[3] Actually an interval exists around any nonconvex kink point which cannot represent desired hours. The width of the interval depends on the curvature of the indifference curve as well as difference in tax rates on the adjacent budget segments.

[4] The two sources of stochastic variation, η and β, are assumed to have zero covariance.

[5] The probability of some of the terms in the sums of equation (4.3) may well be zero especially in the nonconvex case where whole budget segments may be skipped and non-convex kink points cannot correspond to desired hours.

[5a] While it is difficult to construct a nonlabor income measure, the attendant errors in variables problem is vastly reduced due to the use of virtual incomes, e.g., Figure 1.2, along all but the first budget segment. Since the tax system creates a large variance in virtual incomes for each individual, econometric analysis indicates that for most individuals errors of measurement in nonlabor income should not be particularly serious. The treatment of virtual incomes may well explain our substantially larger coefficient of nonlabor income than previous studies have found. If taxes are not accounted for, errors in measurement can lead to a substantial downward bias in the estimated coefficient.

[6] For these calculations we use the mean β for Table 4.1 to be -.178. Mean nonlabor income is 1.266 while $z\gamma$, from equation 4.1, is estimated at 2.59.

[7] In fact, for our calculations presented here the triangle formula for deadweight loss underestimates the exact amount by approximately 200%. The reason for the large difference is that the income effect, which the triangle formula neglects, is the most important factor in causing the deadweight loss.

[8] Hall's (1973) results for the SEO also indicate the presence of an income ffect for males. However, his results are difficult to compare with the findings presented here due to his method of treating nonlabor income in the presence of taxes. But it is interesting that Hall is the other study which attempts to account for taxes and does not constrain

the income effect to a preassigned value. Thus, the current study and Hall's results do confirm the hypothesis that an income effect for males appears when the effect of progressive taxes is entered into the model of labor supply. Burtless-Hausman (1978) also found an important income effect for black male heads of household in the Gary NIT experiment.

[8a] A possible problem exists since we have no measure of fringe benefits. Fringe benefits may be significantly higher for full time workers even if no difference in the market wage exists.

[9] Rosen (1976) found marginal evidence but the empirical magnitude of his relationship was not large.

[10] This approach follows Hanoch (1976) and Heckman (1976).

[11] Rosen (1976) finds an elasticity which exceeds 2.0, but this estimate seems distinctly high. It may result from incorrect adjustment for virtual incomes or not taking account of the limited dependent variable.

[12] The calculations are somewhat more difficult to interpret here than for husbands. Low β wives are much more likely to work than are high β wives. By doing this calculation at sample means we are probably underestimating deadweight loss for working wives and overestimating deadweight loss for nonworking wives. It is difficult to determine if we are close to the population average. A full scale simulation over the population is needed, but the computer funds required to do so are beyond our present resources.

[13] It is important to reiterate that we use the non-SEO part of the Income Dynamics data set which results in our rather small sample. However, inclusion of SEO individuals would raise probablems of sample selection bias since earnings for SEO indoviduals are less, other things taken as equal.

[14] In my study for Gary females labor force participation was about 28% while in this sample labor force participation is 81%. Thus the samples represent two different populations and cannot be strictly compared.

[15] We only consider the effect of tax reform on husbands due to limitations on computer funds. Similation computations could be done for wives and female heads in a straightforward manner.

[16] It is 6.1% of net earnings after taxes and 5.2% of pretax earnings.

5. High Income Groups

Considerable interest has arisen over potentially large work disincentive effects on two economic groups: very low income and very high income groups. Both groups face high marginal tax rates on earned income; usually the marginal rate is .5 or higher. Our knowledge of the effect of the high marginal tax rates on low income groups has been increased considerably by government-constructed cross section data sets and most importantly by the four negative income tax experiments. The results of these NIT experiments will be considered in the next section. Yet very little reform of the tax system and its treatment of low income individuals has been accomplished. On the other hand, our knowledge of the effect of high marginal tax rates on high income groups has advanced little in the past decade.[1] Yet significant changes in the tax systems as they affect earned income for high income groups has taken place. The United States lowered the maximum marginal tax rate on earned income from .7 to .5 in 1969, and the Thatcher government in England has also significantly redued the highest marginal rates in 1979. But no convincing empirical evidence exists that the decrease in the marginal rate had a significant impact on labor supply in the United States. While high income groups certainly complain loudly about taxes, none of the surveys which we will summarize have found a significant disincentive effect of the high tax rates. Thus we might conclude that a convincing efficiency argument does not exist for lowering the marginal rates of high income groups, but vertical equity considerations have probably been foremost in legislators' deliberations.[2]

Almost all of our empirical knowledge of the effect of taxation on the labor supply of high income groups arises from interview surveys. An important sample selection problem exists which has remained almost unnoticed except by Holland (1976). Since we would expect on average high income groups work more, those individuals who are led to work less by the disincentive effect of the tax system are less likely to be surveyed. Thus, a sample selection bias exists for the finding of a small disincentive effect. And a small disincentive effect has been the overwhelming finding of the interview surveys. Yet the empirical results have been so striking, that is is probably safe to conclude that the sample bias is not giving a spurious result. For instance, it does not appear that within the surveys that the highest income groups are affected to a lesser extent than lower income groups. Thus, the primary finding of the survey literature is that while a disincentive does exist, its likely magnitude is not especially large.

The classic study in disincentive effects on high income groups is Break's (1957) survey of lawyers and accountants in Great Britain. Break conducted 306 interviews on a group of individuals both familiar with and having the ability to react to the disincentive effect of the high marginal tax rates which existed in Great Britain at that time. Break found that the majority of the respondents were not significantly affected by the tax system on their work effort. Of the 49% who reported an effect, only 18% cited disincentive effects while 31% cited an incentive effect from the tax system. Thus, the overall income effect dominated the substitution effect for these individuals.[3] Using a much more stringent criterion where the interpretation of the sample responses was clearest, Break concluded that 14% of the sample were significantly affected by taxation. The tax incentive effect still predominated with 8% of the original sample working harder because of the tax effect. Still, Break concluded that a small net disincentive effect might exist because the 6% who reported a significant disincentive effect had higher earnings than the 8% who reported an incentive effect.

Break's original study has been repeated by Fields and Stanbury (1970, 1971). Fields and Stanbury find a significantly higher percentage of respondents report a disincentive effect than did Break. They concluded that the disincentive effects had become more important over time as individuals had adjusted their labor supply slowly to the continued high marginal tax rates. But, on the other hand, the 6% who showed significant disincentive effects in Break's survey had fallen to only 2% which those individuals with significant incentive effects had also declined markedly. Both studies do find that disincentive effects increase with income yet we might well conclude that this finding primarily arises from an income effect, not a substitution effect. The single important quantitative finding in the Fields and Stanbury survey is that no significant difference exists between average number of hours worked among groups of individuals who reported disincentive effects, incentive effects, or no significant tax effects. Thus, whatever net effect may exist its likely empirical magnitude is small.

Similar interview survey of American business executives have been conducted by Sanders (1951) and by Holland (1969). From his interviews of 135 business executives and 25 professional men, Sanders found the effects of taxation to be quite small. Sanders concluded that important non-financial incentives more than outweight the change in financial incentives that taxation creates. Probably the most important effect of taxation that Sanders found was the amount of time used in creating responses to taxation through investment and tax avoidance programs. The economic cost of this type of response is probably substantial and has undoubtedly increased in magnitude since Sanders' survey.[4]

Holland (1969) conducted interviews of 125 business executives in which he attempted to isolate the substitution effect by considering a hypothetical tax on potential income. The amount of the tax would be about the same as the tax paid currently. However, it appears to me that the effort is not totally successful because of the nonlinearity of the budget set discussed in Section 1. There we pointed out that the Slutsky equation does not adequately describe the tax response because of the presence of virtual incomes different from nonlabor income. Thus, Holland's technique would seem to be exactly correct only in the case of a proportional tax system.[5] Holland's findings are much in line with previous results. The hypothetical change in the tax system would have no effect on 80% of the sample. Fifteen percent of the sample indicated they would work harder while one individual claimed he would work less hard. Holland seems to conclude that on average a tax incentive effect exists, at least in the substitution effect. But he concludes also that the magnitude is likely to be small. Thus, his results accord well with the Break results and Sanders results.

The last sample interview we consider is Barlow, Brazer, and Morgan (1966). They conducted 957 interviews with individuals who had income exceeding $10,000 in 1961. They also attempted to include a disproportionately large number of very high income people in the sample. Their results are again very similar to previous findings. Approximately 88% of the sample individuals responded that the income tax did not effect their work effort. Among the 1/8 of the sample which reported disincentive effects. Barlow, et.al. concluded that the actual magnitude of the disincentive is likely to be very small. In fact, they estimated the total effect on the economy to be of the order of .3% in 1963. Given the rather different sample coverage the Barlow results seem quite similar to the results found in the other studies.

From these results we should not reach the too sanguine conclusion that high marginal tax rates may not have a significant economic cost. We have already mentioned the large amount of effort that goes into shifting ordinary income into capital gains which are taxed at a much lower rate. Evidence of considerable economic waste appears periodically from these schemes. But, the important point to note here is that these machinations seem to have very little effect on work effort. Presumably, for most people it is very difficult if not impossible to shift compensation from working directly into capital gains. Furthermore, the sensitivity of their work response is quite low to a given marginal tax rate. Perhaps these results are not too surprising. For both non-high income individuals who are not secondary earners and also for low income individuals, the work disincentive effects is found to be small in econometric studies. Previous findings that, if anything, the income effect predominates is in accordance with Break's findings. Thus, in terms of work response it does not appear that the rich are different than the rest of us. But, they do have more money.

NOTES

[1] The last significant survey is Holland (1969). Also, the most recent extensive survey of the literature is Holland (1976).

[2] Certainly large amounts of economic resources are used to lessen the burden of taxation by using the capital gains provisions of the tax laws. But this observation has little bearing on the work effort of the high income groups themselves.

[3] From a social welfare analysis point of view, little comfort arises from these findings. It is important to remember that only the substitution effect creates deadweight loss. Thus, even if the income effect is large enough to outweigh the substitution effect, considerable deadweight loss may still exist.

[4] Executive compensation through stock options and other non-wage compensation become an effective and important method of partly avoiding the high marginal rates. But the combined effect of the .5 tax limit on earned income in the 1969 Tax Reform Act and the 1976 Tax Reform Act provision for stock option plans may decrease the importance of non-wage compensation.

[5] It is the case that Holland will find the sign of the substitution effect. However, his work cannot be used to estimate empirical magnitudes.

6. Evidence from NIT's and Social Security Effects

Four negative income tax (NIT) experiments have been conducted by the government to produce information about the likely effects on labor supply of replacing the current welfare system by an NIT. Three urban experiments took place in New Jersey, Gary, Indiana, and Seattle-Denver. A rural experiment also took place in Iowa and North Carolina. We review only the urban experiments since we have excluded farms from our previous analysis.[1] In principle, the NIT experiments might seem to be an ideal laboratory in which to determine the effect of taxes on the labor supply response of low income workers.[2] Observations were recorded on individuals before the experiment began, and during the three year period of the experiments two groups were observed. The experimental group was subject to an NIT plan while a control group received nominal payments to participate in the experiments. Yet the initial results were not clear cut. Analysts found the results disappointing. A. Rees, in his summary of the New Jersey results, concluded that "the differences in work behavior between experimentals and controls for male heads...were, as we expected, very small. Contrary to our expectations, all do not show a clear and significant pattern; indeed they show a discernable pattern only after a great deal of refined analysis."[3] Unforeseen problems did arise which, in retrospect, is not surprising since the New Jersey NIT experiment was the first social experiment ever conducted. Statistical problems which arise in conducting experiments with human subjects over time had not been accounted for. For instance, the attrition problem in the New Jersey experiment almost certainly accounts for the anomalous results found for black and hispanic males. Subsequent analysis of the New Jersey and other two urban NIT experiments has led to more definite conclusions about the labor supply response. We will give a brief review of the evidence.

We first consider the evidence for male heads of households. Two important differences from the non-NIT framework arise for the analysis. Contrary to the usual case of analyzing the effect of taxes on labor supply where the substitution effect is considered to be much more important than the income effect, both the income and substitution effect are important for an NIT. The expected additional cost of an NIT program over the existing welfare program is a crucial consideration. Thus, we are very interested in the overall labor supply response rather than just the distortion created by taxation. The second difference is that for males both the income and substitution effect work to reduce labor supply. In Figure 6.1 we show how the NIT alters the budget set.

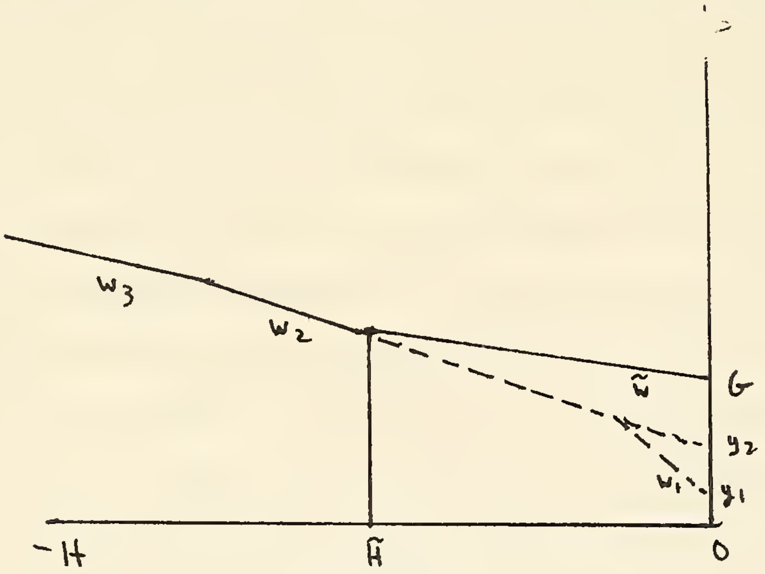

Figure 6.1

Non-labor income y is replaced by the NIT guarantee G which will have the effect of reducing labor supply for an individual who was initially on the first budget segment so long as leisure is a normal good. At the same time the net wage w_1 which was subject only to FICA contributions now is lowered to $\tilde{w}$ which is subject to approximately a .5 tax rate. Thus, labor supply will be reduced since the NIT budget segment lies uniformly above the first non-NIT budget segment.[4] For individuals initially on the second segment but below breakeven hours $\tilde{H}$ the same reasoning holds. Non-labor income has risen from $\tilde{y}_2$ to G and $\tilde{w}$ is less then w_2. Lastly, many individuals above breakeven hours $\tilde{H}$ will not change their labor supply at all, but others will shift down below $\tilde{H}$ because of the income effect of the guarantee.

In fact, the findings agree with this economic theory. The labor supply reduction in hours worked for white males in New Jersey was about 4% uncorrected for attrition, In Gary for black males it was about 6% uncorrected for attrition and 10% when corrected for attrition, and in Seattle-Denver the response was 5% uncorrected for attrition. While these overall results are of interest, they are not sufficient for policy purposes. They are an average response over the many NIT plans used in each experiment.[5] To obtain reliable cost estimates, it is necessary to construct a model which permits determination of income and substitution effects. Then the cost of different plans can be forecast from the estimated parameters.[6]

Hausman-Wise (1976) was the first paper which took explicit account of the form of the NIT budget set in constructing an empirical model.

They used an instrumental variable procedure to predict the net wage and virtual income along with a budget segment and estimated a log linear labor supply specification for white males in the New Jersey experiment. They found an uncompensated wage elasticity of .14 and an income elasticity of -.023. Thus both effects in Figure 6.1 have significant effects in reducing labor supply. The poverty level for a four person in New Jersey was $3,300. Thus for an individual who received the poverty limit as the guarantee and faced a 50% marginal tax rate the uncompensated wage effect would lead to an expected labor supply reduction of about 8% while the income response would lead to an expected reduction of between 10-16% if the person had initially been on the first budget segment. Taking midpoints we would have an overall expected response of 21% in labor supply. For an individual initially on the second segment he might have no response to an NIT at all. For those initially below breakeven hours $\tilde{H}$ on the second segment the wage effect is 6% with the income effect leads to a reduction of 1% so that the overall response is about 7%. Taking weighted averages of the two responses leads to an expected labor supply reduction for those individuals below breakeven hours of 16.1%. It is very important to note that the model predicts only 17.6% of the population will fall below breakeven so that the overall population response is about 4%.[7] Some confusion has arisen over the response conditioned on being below breakeven hours and the overall population response. The latter response is appropriate for cost estimates of an NIT.

Burtless-Hausman (1978) analyze the labor supply response among black males in the Gary NIT experiment. They use a procedure to treat taxes very similar to the technique used in Section 4 except for the choice of a log linear labor supply curve. In particular, they treat the budget set as exogenous rather than using an ad hoc instrumental variable procedure and they also allow for a distribution of tastes in the population. Here in Table 6.1 we present their results for both control individuals and for experimental individuals on a weekly basis for the mean individual in the sample. We first note that breakeven hours are quite high for some of the plans so that the individual will almost certainly be below breakeven. Also note that a significant dispersion exists in the expected response - it is about 13% for low wage groups. Perhaps even more importantly the distribution of tastes parameter indicated that most of the response takes place via the income effect for a small number of individuals. The great majority of individuals do not significantly alter their work response so that the effect of the NIT leads to a very skewed response in the population. On the other hand, the uncompensated wage change has very little effect. We can see the income and substitution effect by comparing the rows which correspond to a $2.25 wage since the individuals will always be on the first budget segment. No difference in response at all is found for the .4 or .6 tax rate while the high guarantee leads to a 9% greater response than does the low guarantee. At higher wage rates the amount of the tax does play a role, but only because it changes the amount of breakeven hours and thus the probability of being above breakeven. The finding

TABLE 6.1

LOCATION OF 15 BUDGET LINES IN GARY EXPERIMENT

Financial Plan and Gross Wage/Hr ($)	w_1 ($)	w_2 ($)	y_1 ($)	y_2 ($)	Hours at Kink Point	Expected Hours	Change from Control (%)	95% Confidence Range of Expected Hours	Probability of below Break-even Point
Control:									
2.25	2.07	1.67	2.72	27.82	43.16	43.55	...	36.8, 45.38	...
4.25	3.92	3.15	2.72	27.82	22.85	40.37	...	36.8, 45.38	...
6.25	5.76	4.63	2.72	27.82	27.82	40.34	...	36.8, 45.38	...
40% tax/low guarantee:									
2.25	1.35	1.67	78.63	27.82	159.59	38.68	-11.8	34.15, 44.95	1.0
4.25	2.53	3.15	78.63	27.82	81.77	38.68	-4.3	34.15, 44.95	1.0
6.25	3.75	4.63	78.63	27.82	57.45	38.68	4.2	34.15, 44.95	1.0
60% tax/low guarantee:									
2.25	0.90	1.67	78.09	27.82	65.42	38.69	-11.8	34.17, 44.96	1.0
4.25	1.70	3.15	78.09	27.82	34.63	39.62	-1.9	34.16, 43.48	.21
6.25	2.50	4.63	78.09	27.82	23.55	40.23	-.3	34.16, 45.38	.02
40% tax/high guarantee:									
2.25	1.35	1.67	102.63	27.82	234.97	38.27	-12.9	33.50, 44.85	1.0
4.25	2.53	3.15	102.63	27.82	120.39	38.27	-5.3	33.50, 44.85	1.0
6.25	3.75	4.63	102.63	27.82	84.59	38.27	-5.3	33.50, 44.85	1.0
60% tax/high guarantee									
2.25	.90	1.67	102.09	27.82	96.66	38.29	-12.9	33.50, 44.84	1.0
4.25	1.70	3.15	102.09	27.82	51.17	38.29	-5.3	33.50, 44.84	1.0
6.25	2.50	4.63	102.09	27.82	34.86	39.38	-2.4	33.50, 45.38	.23

that the income effect is the major determinant of labor supply reduction among Gary males was also found by Moffitt (1978) who used a quite different probit type of model. The results differ markedly from the Hausman-Wise findings for New Jersey where the income effect explained about 68% of the change in hours. It would be interested to determine if this result occurs because of different model specification or because of a fundamentally different response pattern among the two populations.[8]

The final labor supply results for males that we review are the findings of Keeley, et.al for the Seattle-Denver experiment. While the Seattle-Denver experiment is superior in certain respects from the other urban experiments, I find the ad hoc method used by the authors to treat the budget set not to be entirely satisfactory. They use a first difference specification where the change in income is done at pre-experimental hours of work for the individual as is the change in the net wage rate. Since pre-experimental hours are an endogenous variable, an important simultaneous equation bias may be introduced.[9] However, the magnitude of the bias is difficult to estimate. At the mean of the sample Keeley et.al. found the income effect to explain 46% of the reduction in hours while the change in the wage explained the other 54%. These results differ markedly from the results in the New Jersey and Gary sample where the change in non-labor income is the more important determinant of the reduction in labor supply. Again, it would be interesting to ascertain whether the different results arise because of the model used.

The other group whose labor supply supply might be markedly affected by introduction of a NIT is working wives. Neither the New

Jersey nor the Gary experiments had sufficient number of working wives to allow model estimation. Keeley, et.al. find an average response elasticity about four times as large for wives as for husbands. The mean labor force reduction is 22%. Here the change in income accounted for 75% of the total effect. Since most of these women presumably had working husbands, such a large scale withdrawal from the labor force could be an important effect of an NIT.

The last group to be considered is female headed households. Most of the affected population qualifiers for AFDC so that introduction of an NIT leads to a substantially higher guarantee and somewhat lower tax rate under most NIT plans. Keeley, et.al. found the female heads response to be about twice as large as the male response. The mean labor force reduction is 11%. Here they found the income effect to explain about 66% of the total response. Hausman (1979) in a study of labor force participation among black females who headed households in Gary again found the level of the guarantee to be much more important than the NIT tax rate. For instance he finds that the change from a .4 to .6 NIT tax rate reduces the probability of participation by about 2.5% while a change in the NIT guarantee from .75 of the poverty limit to the poverty limit reduces the probability of participation by 6.5%. In terms of comparing the expected effort to that of AFDC it seems likely that a reduction in labor supply would result. Even if the marginal tax rate fell from the AFDC level of .67 to an NIT level of .4 the accompanying higher benefits would create a net disincentive effect. The net result would be a significant increase in the cost of family support for female headed households. At the same time the extra income which would go to the lowest income group in the economy might well lead to a net gain in social welfare.

The other literature which we review is the effect of the social security earnings test on retirement behavior and labor supply. We discussed the social security beneficiary budget set in Section 3 where we emphasized the intertemporal aspects of the model. A recent theoretical paper which attempts to include many of the intertemporal aspects is Sheshinski (1978). However, he concentrates on the effect of saving on the retirement decision and does not include the effects of the earnings test in the model. An important empirical fact does appear with respect to social security. Labor force participation has decreased among the elderly over the postwar period in the United States. From 1960 to 1975 labor force participation for males over 65 fell from 33% to 22%. Over the same period for men aged 62-64 it fell from 81% to 60%. 1961 is the year in which Social Security eligibility for men 62-64 was introduced. It seems very difficult to sort out the influence of social security benefits, private pensions, and the work disincentive of the earning test.[10] Remember, in Section 3 we questioned whether a work disincentive from the combined effect of the earnings test and benefit recomputation actually existed. Published empirical work is just beginning to appear which attempts to sort out the three influences on retirement. However, private pension data is often difficult to obtain. Since the asset value of a private pension increases with time its influence can be quite important. Furthermore, the combined effect of the earnings test and benefit recomputation seems difficult to model. But given the great interest in the elderly which represent an increasingly large proportion of the population the questions seem an important area for research.

Quinn (1977) considers the determinants of early retirement among white married men who are 58-63 years old. In his model of labor force participation he attempts to model the budget set by including dummy variables to indicate eligibility for social security and for private pensions. Unfortunately, he uses the gross market wage rather than the net, after tax wage so that the effect of the earnings test is impossible to determine. Quinn's major finding is that eligibility for social security and private pensions are extremely important determinants of retirement. The flow of asset income is also an important determinant of the retirement decision in his results. Thus, we can conclude that the income effect is probably quite important in a retirement model. Quinn finds that no important effect arises from the gross wage; but since he has not accounted for the earnings test, the findings cannot be accepted.

The other empirical study is Boskin-Hurd (1978) who consider a three state model of working, semiretirement, and retirement. The middle state corresponds to receiving social security benefits and working, thus being subject to the earnings test. To account for nonlinearities in the budget set as was discussed in Section 3, they use a fourth-order polynomial in the gross wage and third-order polynomials in non-labor income. They do not appear to have data on private pensions which Quinn found to be quite important. Boskin-Hurd is the first paper to include the effect of taxes on retirement; however, their rather ad hoc polynomial approximation procedure does not seem totally satisfactory. In particular, they do not account for the virtual income along a budget segment which corresponds to a given net wage. Thus, we find it difficult to sort out the income and wage effects in their results and the effect of the earnings test.[11] Boskin-Hurd do find an important effect on retirement from the benefit level. They also find that an increase in the gross wage decreases the probability of retirement. However, they find the surprising result that a higher net wage leads to an increase in the probability of semiretirement. Also, the sign of the benefit variable seems contrary to economic theory in the semi-retirement results. Thus, the Boskin-Hurd results seem satisfactory on the retirement decision. However, the semi-retirement decision where the earnings test presumably has the most impact needs further work. Thus at the current stage of the model we cannot ascertain how large the disincentive effects of the earnings test are. Nor can we determine the size of the income and substitution effects.

In this section we have considered the empirical evidence from the NIT experiments. Although numerous statistical and econometric problems arise, I feel we have learned much about labor supply behavior of low income workers. We now return to our question of the last section. There, we decided that labor supply behavior of high income persons was not too different than middle income individuals. What about low income people? From the experimental results, I conclude that the income effect is probably larger than we previously had thought. Especially for male heads of households I feel that introduction of an NIT would have a significant impact on labor force supply reduction by a small proportion of the population. I doubt that the NIT tax rate is nearly as important as the level of the NIT guarantee. Thus, low income males do have low wage elasticities as does the rest of the population; but their income elasticies may be significantly higher.[12] Similar results were found for female headed households although they presently have AFDC so that the change might not be as large. Lastly, the NIT results for wives seem quite different than the usual results. Their wages elasticities are much lower and income elasticities are much higher than had been found for middle income wives. But, the evidence on wives is based on only one sample and one estimation technique. More research needs to be done on wives behavior under an NIT before we can be confident about the results. Social Security earnings test research is in an even earlier state of development. We still need a model that can account for both the intertemporal aspects of the problem and the form of the entire budget set.

NOTES

[1] A further problem exists since the results from the rural experiment seem extremely difficult to interpret. A volume of papers on the rural experiment is found in

[2] All the experiments were designed basically to measure labor supply elasticities. However, other interesting areas of research such as family consumption patterns and family stability have been studied.

[3] For a series of papers on the New Jersey experiment see the Spring 1974 volume of The Journal of Human Resources.

[4] So long as the NIT segment lies uniformly above the previous budget segment the net change in income must be positive. Thus, the income effect will reinforce the substitution effect and cause a reduction in labor supply, Thus, the level of the guarantee removes the usual indeterminancy of the effect of a change in the net wage.

[5] Unfortunately, insufficient subjects were included in each cell of the experiment to use classical ANOVA techniques to compute an accurate estimate of the response to each NIT plan. Statistical problems which arose during the design and duration of the experiment may preclude use of these techniques anyway. See Hausman-Wise (1977, 1979a, 1979b).

[6] Two potential problems arise in using the experimental results to produce cost estimates. First, the demand side of the market could change significantly for a nationwide NIT. In particular, individuals could choose work patterns to convexify their budget sets by working and not working in alternative accounting periods. Also, the limited duration ot the experiment may miss important long range effects on both the supply and demand sides of the labor market.

[7] The low proportion below breakeven is due to the study of white males who were relatively well off in New Jersey and Pennsylvania.

[8] The finding that it is the income effect which creates almost the entire labor supply response is corroborated further by the results of Hausman-Wise (1979a) who consider a model which corrects for attrition.

[9] A further problem exists since people initially above breakeven hours will not have their net wage or income affected by the experiment. The authors attempt to treat this problem by including a dummy variable which again would create simultaneous equation bias.

[10] Another possible reason for decreased labor force participation is poor health from illnesses which previously would have caused death. However, the influence of health does not seem large enough to explain the participation changes. Also, a large proportion of the elderly are in better health than in previous periods. My feeling is that average health for a given age has probably improved over the postwar period.

[11] Boskin-Hurd recognize this latter problem and report they are working on a simulation program to attempt to infer the effect of the earnings test.

[12] Middle income individuals may have higher income elasticities than found in previous work since these studies do not correctly represent the budget set.

7. PREVIOUS EMPIRICAL RESEARCH

Empirical research which allows for taxation to affect labor supply is all quite recent. The older labor supply literature allowed for an effect of a gross market wage on labor supply and sometimes used non-labor income also as a regressor. However, the effect of taxes was not explicitly introduced. In fact, in the interesting Cain and Watts (1973) volume which concentrated on the effect of a NIT on labor supply, almost all the papers used the market wage in estimating labor supply functions so that taxes were not accounted for. Kosters (1966) did introduce taxes into a labor supply model but used average tax rates to stay within a linear budget set framework. In his reported empirical work, he too used the market wage.[1] Thus, the previous literature was estimating labor supply curves without taking account of taxes.

Initial attempts to account for the effect of taxes was made by Diewert (1971), Hall (1973) and Wales (1973). These three papers all considered the case of a progressive tax system so that the budget set is convex. A linear approximation to the budget set was used to account for taxes. That is, observed hours of work were used along with the market wage to establish the marginal tax bracket and the net, after tax wage. This observed net wage along with the corresponding observed virtual income was then used in the estimation of the labor supply function. Accounting for taxes by linearizing the budget segment marked an important advance over the "reduced form" approach which had been previously used. In a nonstochastic model it is strictly correct since the individual would make the same choice over the linearized budget constraint as he would over the full nonlinear budget set. However, in a stochastic model where hours worked is a random variable, problems arise. Correlation between the right hand side variables and the stochastic disturbance is introduced by this technique. The net, after tax wage now is a nonlinear function of the left hand side variable. Virtual income is similarly correlated with the stochastic disturbance. While the size and direction of the bias is difficult to calculate because of the nonlinearity of the budget set, linear approximations indicate that the wage coefficient is likely to be downward biased while the income coefficient is likely to be upward biased. The size of the bias depends on the relative size of the variance of the stochastic disturbance versus the variance of net wages and virtual income. But since the variance of the stochastic disturbance is typically found to be sizeable in empirical work, the bias is potential large.

An instrumental variable procedure which accounts for the simultaneous equation bias of the linear approximation method was first used by Hausman-Wise (1976) and Rosen (1976b). Here a nonlinear reduced form equation which excludes the net wage and virtual income is used to form a conditional expectation of hours worked for each individual. Then the net wage and virtual income which correspond to the predicted budget segment are used as instruments for the observed net wage and virtual income from the linear approximation.[2] In his paper Rosen employed an interesting test of tax perception by testing whether the coefficients of the market wage variable and the tax variable were the same. He could not reject the hypothesis of equality leading to the conclusion that individuals do perceive the effect of taxes and react to the net, after tax, wage rather than the market wage.

While the instrumental variable procedure does offer a simple computational approach, it is not totally satisfactory. The linear approximation uses only local budget set information while the individual is maximizing over a global budget set. For instance, the conditional expectation of the labor supply equation may have hours which lie off of the budget segment whose net wage and virtual income appear on the right hand side. Forecast hours are then inconsistent with budget segments which are used to form the forecasts. Thus, potentially important information is neglected and inconsistencies are not accounted for. More importantly, the approach does not adequately account for the corners of the budget set which occur at kink points. Preferred hours are more likely to occur at kink points for a given family of indifference curves, but the instrumental variable approach neglects this fact. Lastly, nonconvex budget sets cannot be adequately treated. The instrumental variable procedure cannot account for parts of budget segments which are not utility maximizing points. The most recent techniques can account for these additional factors although only at the expense of more complicated nonlinear estimation techniques. But given the nonlinearity of the budget set, the requirement of more complicated statistical techniques should not be surprising.

The latest techniques to account for taxes have been developed by Burtless-Hausman (1978), Wales-Woodland (1979), and Hausman (1979a). These approaches consider the complete budget set in computing preferred hours rather than using only a local approximation. Wales and Woodland begin with a CES utility specification and consider the case of a convex budget set only.[3] Burtless-Hausman and Hausman consider both convex and non-convex budget sets. They begin with a specification of labor supply and derive the associated indirect utility function by using Roy's identity. The non-convex budget sets may arise from non-convexities in the tax system or from the presence of fixed costs to working. These papers also allow for a distribution of preferences in the population. We will not describe the models in more detail since they are discussed at length in the previous sections of the paper. The shortcomings of the local methods seem to be overcome with these more sophisticated models. The main drawback is computational. However, further research in the area should allow for more general specifications with less computational burden. By requiring that the conditional expectation of preferred hours is consistent with the associated net wage and virtual income, an important element of specification consistency is introduced. I see this consistency aspect as perhaps the most important advance of the global models over the local approximations. We can also then use the results to forecast what the effect of an altered budget set would be, e.g., a projected change from one NIT system to another. The local approximation models do not have this forecasting capability since they cannot forecast the appropriate budget segment after the shape of the budget set has changed.

NOTES

[1] In personal correspondence Kosters states that he had experimented with both on average and marginal tax rate. However, he did not report the results since he felt that no additional information was provided within the linear framework he was working in.

[2] Because of the nonlinearity it is important to do actual instumental variable estimation not two stage least squares estimation. The latter estimator leads to inconsistent results.

[3] Their results seem rather surprising. Their wage elasticity for a sample of male heads of households is near unity. In fact, they do not reject a Cobb-Douglas specification. Yet, virtually all other empirical results for males, including the results reported in this paper find a very low wage elasticity. In fact, zero would not be far from the mean result of other studies.

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